CALIFORNIA AGRICULTURAL EXTENSION SERVICE
CIRCULAR 125
Revised JUNE, 1949

IRRIGATED PASTURES IN CALIFORNIA

BURLE J. JONES and J. B. BROWN
Revised by MILTON D. MILLER and L. J. BOOHER

Beef cattle on irrigated pasture

THE COLLEGE OF AGRICULTURE
UNIVERSITY OF CALIFORNIA · BERKELEY

AN IRRIGATED PASTURE

...can help you diversify and balance your farm operations—and conserve your soil.

IRRIGATED PASTURES provide an important part of the forage for California's meat and dairy herds. California does not raise enough livestock to meet the needs of its rapidly expanding population. In 1948, we imported 80 per cent of our pork requirements, 50 per cent of our beef needs, 35 per cent of our lamb and mutton, and nearly all of our butter.

Some California farm crops are already in overproduction. More probably will be. Some of this "surplus" acreage might be profitably converted to irrigated pastures and the production of more livestock.

Under Good Management, an Irrigated Pasture Provides:

1. Conservation and improvement of soil resources.
2. Cheaper, more nutritious feed for livestock.
3. Low harvest costs, because livestock harvest their own feed.
4. Some saving in protein feed supplements.
5. Better gains in young stock.
6. Higher production in a breeding herd.
7. More economical gains in market animals.
8. A more evenly distributed farm labor load over the year.

When Planning an Irrigated Pasture, The Grazier Must Consider:

1. **SOIL AND CLIMATE.** The site must lend itself to irrigation and to one of the mixtures of species suitable for pasturage.
2. **THE SIZE OF THE FARM.** Unless only part-time use of the pasture is possible, there must be enough acreage for rotation grazing. A balance of year-round feed supplies of hay, concentrates, and pasture should be maintained.
3. **THE KIND AND QUANTITY OF LIVESTOCK.** Irrigated pastures may be desirable for special uses only, such as for a breeding herd or flock, or to fatten for market.
4. **THE COSTS, WHICH INCLUDE:** (1) installation of the irrigation system, which will vary with type of soil and natural topography of the land; (2) irrigation water needed, the amount depending upon soil, climate, and length of irrigation season; (3) labor costs for irrigation, which depend on the type of system installed. (A full discussion of average costs will be found on page 41.)
5. **PRODUCTION.** An irrigated pasture should yield as large a tonnage of feed per acre as alfalfa, but should be more economical in harvesting and feeding costs—in terms of livestock gains, 400 to 500 pounds per acre per year.

The Goals of Good Pasture Management Are:

1. To produce as much meat or milk per acre as possible.
2. To obtain and continue the highest possible grazing capacity of animal units per acre.
3. To use the feed at its highest possible nutritive value.
4. To maintain an adequate stand and balance of legumes and grasses throughout the pasture season.

These Goals May be Achieved by:

1. Wise use of available irrigation water.
2. Rotation grazing so that plants are eaten when their nutritive content is highest—and will have a chance to recover after grazing.
3. Mowing pastures during the spring months when there is a surplus of forage. This adds to hay supplies, helps reduce weeds, and controls the coarse growth which has sprung up around cattle droppings.
4. Harrowing, to scatter manure droppings.
5. Fertilizing.
6. Weed control.

Recent Studies Show That

. . . irrigated pastures may not provide enough dry matter, and therefore dry roughage supplements may be necessary to keep down bloat hazard in cattle and sheep and to promote satisfactory gains.

. . . the supplemental grain fattening of beef cattle on irrigated pasture looks like a good proposition under certain situations.

. . . forage from irrigated pastures is usually more expensive than that from natural range, but is a cheaper source of nutrients than most other livestock feeds. Dairying particularly could be made more profitable by using more irrigated pastures.

. . . California ranges are being improved by the shifting of part of their summer burden to irrigated pastures.

Interested in a special phase of irrigated pastures?

SEE TABLE OF CONTENTS ON PAGES 58 AND 59.

The authors wish to thank Professors B. A. Madson and M. L. Peterson, of the Division of Agronomy, Professor F. J. Veihmeyer, of the Division of Irrigation, and Mr. Ruben Albaugh, of the Monterey County Agricultural Extension Service, who reviewed the manuscript and made helpful suggestions.

The Authors:

Mr. Jones is Assistant Professor of Agricultural Extension, Emeritus, Davis.

Mr. Brown was Associate in the Experiment Station, Division of Irrigation, Davis. (Deceased.)

Mr. Miller is Extension Specialist in Agronomy, Davis.

Mr. Booher is Extension Specialist in Irrigation, Davis.

IRRIGATED PASTURES IN CALIFORNIA

BURLE J. JONES and J. B. BROWN

Revised by MILTON D. MILLER and L. J. BOOHER

AN IRRIGATED PASTURE is an irrigated area on which is growing a satisfactory stand of seeded forage plants suitable for grazing by livestock. It may occasionally be mowed for hay, or to reduce weeds or coarse clumps about the droppings of cattle. Such pastures are usually made up of a mixture of long-lived grasses and legumes. Sometimes a legume, such as Ladino clover or alfalfa, is seeded alone; occasionally only a grass, such as Dallis, is seeded. But a mixture of legume and grass species is usually recommended for cattle, sheep, and horses. Hogs thrive best on a pasture comprised only of legumes.

Irrigated pastures came into use in California in the early 1930's. An unofficial survey by competent authorities placed the acreage in the state, as of November, 1948, at about 575,000 acres. This included only pasture acreage popularly recognized as "irrigated pasture" (Ladino clover, Ladino clover-alfalfa-grass mixtures). It did not include irrigated mountain meadows, sudangrass, or alfalfa stands which are pastured.

Because the plants generally used have a shallow root system, irrigated pastures are being extensively used in areas of heavy or shallow soil which is frequently underlain with hardpan or tight subsoil clay layers. In such areas, pastures are proving profitable where no other cultivated crop has been permanently successful. On many farms, however, deep fertile soils have been seeded to pasture to balance livestock operations economically between winter and summer feed requirements. Annual feed costs are reduced by allowing livestock to harvest their own feed during the growing season.

Increasingly, California farmers are considering irrigated pastures as a crop in the rotation system. It has been estimated that 8,000 acres of rice land are in a rotation system with irrigated pasture.

Irrigated pastures are now common in the highly productive and high-priced lands supplying some of our larger milk sheds. Plantings in Orange, Riverside, and Los Angeles counties have shown that where water seepage losses are not too high, such pastures provide cheaper feed than green (clipped) alfalfa, or alfalfa hay, and concentrates. Santa Clara, Alameda, and Contra Costa counties, as part of the San Francisco milk shed, use them extensively.

Successful irrigated pastures depend on soil and climate, over-all farm program, costs, production, and kind of stock

Probably the first consideration should be the adaptation of the site to a particular mixture of species. Some mixture can be assembled that will grow on almost any soil where enough irrigation water is available to meet requirements of growing plants during the dry summer. Very shallow soils may be used, for although roots of many grasses strike deeper, most can grow in as little soil as 9 inches.

Adaptability to farm program. The general farm program must be considered in planning an irrigated pasture. This includes the size of the farm, kind of livestock, and the proper balance of year-round feed supplies. On most farms, it probably will be necessary to purchase supplementary feeds, such as hay, silage, and concentrates, or to produce them on other cultivated land. It is not possible to balance stock numbers exactly with the seasonal availability of pasture feeds. The spring flush of pasture growth will probably exceed requirements. The short-production winter months (see page 24) will require considerable stock feeding from sources other than pasture. Unless only part-time use of the pasture is possible, there must be sufficient pasture acreage to allow for rotation grazing.

Many range stockmen are now operating irrigated pastures in connection with their ranges. Their cattle or sheep are moved onto the green irrigated pastures during the summer months after the feed has dried up on the range. At the end of the irrigated pasture season, the stock then return to the range. Such a program, if properly used, can assist in improving California rangelands principally by reducing overgrazing and by assisting desirable resident perennial range species to become reëstablished. Stockmen are also using irrigated pastures for special purposes, such as to provide good feed for weaner calves or lambs, or to fatten stock for market.

Farmers are planting fields to irrigated pasture which until recently produced a cash specialty crop. As surpluses develop in the postwar period, ranchers are converting land used for surplus crops to pasture. This provides a better balanced farming program. Pasture can be used to produce needed livestock products for California's rapidly expanding population. The greater use of pasture is also sound from the standpoint of maintaining the fertility of California farms.

Costs. In figuring costs of feed produced by irrigated pastures, soil preparation, overhead, and maintenance must

Fig. 1.—Even utilization of Ladino clover and grass pasture by dairy cattle. Cattle and sheep pasture should be about 45 per cent legumes, 55 per cent grasses.

Fig. 2.—Hogs do best on a pure legume pasture, but grass-legume pastures (above) are often used. Growing pigs do especially well on pasture. Pasturing hogs should receive a grain supplement.

be considered. Alfalfa is a good standard measure by which to figure probable expense and future returns. If soil, topography, water facilities, and climate are suitable for alfalfa (on the basis of average returns), it is likely that an irrigated pasture crop would also be profitable. Actual expenditures for preparation, seeding, and maintenance vary, depending on topography, water costs, taxes, and upkeep of irrigation structures. (See figures on page 43.)

Production. Alfalfa is also a good yardstick for measuring feed production. An irrigated pasture should yield as large a tonnage of feed per acre as alfalfa, using no more irrigation water or labor, and should be more economical because the livestock harvest their own feed. In general, this is a fair comparison, although there may be a few exceptions.

Where an irrigated pasture is grown on soil too shallow for alfalfa, the comparison still holds—production should equal a fair yield of alfalfa.

Pasture production should be judged by average returns for several years, not by returns for one season only. Alfalfa producers, for example, are able to make a frequent check during irrigation and harvesting operations, and the harvest itself gives a fairly accurate record of annual yields. Pasture operators, on the other hand, do not have occasion to make such check-ups, since there are no bales or sacks to weigh. However, progressive stockmen now own livestock scales with which they weigh stock on and off their irrigated pastures. Valuable records of gain in weight are thus being obtained and the graziers concerned know where they stand. Weeds may creep in, composition of the mixture may change, and total yield may decline without the operator's knowledge if no in and out weights are obtained.

Production in terms of animal units per acre varies widely, depending on certain fixed soil, climatic, and irrigation limitations beyond the control of a prospective operator. These should all be considered in determining whether an irrigated pasture is economically sound. Once the pasture is established, management practices should be regulated to maintain high production. Few California pastures show a lower carrying capacity than one animal unit (1 mature cow) per acre for the grazing season (8 to 11 months). Some pastures carry as high as two or even three units per acre per season. Under proper management, most of the pastures in this state should support two animal units per acre, if the mixture and stand are adequate.

Fig. 3.—Sheep on contour-basin irrigated pasture. They do well on grass-legume type used for cattle.

Improvement in livestock and income. Livestock improvement should begin with a well-planned and properly conducted feed production program. Next in importance is a sound breeding program. For the dairyman, a good irrigated pasture, grazed at the right stage of growth for maximum nutritive values, has been shown to produce more milk than does hay, or even hay and concentrates. And the saving in the cost of harvesting and feeding often means the difference between profit and loss.

With irrigated pastures, the range operator may increase both the quantity and the quality of his output, through better gains in young stock, a higher production in the breeding herd, and more economical gains in market animals. While he may appear to be substituting higher-priced feeds for range forage, he will be effecting a saving in protein and grain supplements. He can be improving the productivity of his range if he properly coördinates the grazing program on the range with his irrigated pastures.

Land Preparation and Irrigation

Types of irrigation vary, depending upon differences in the soil, land contours, and the amount of water that is available

The purpose of land preparation is to provide for the most economic and uniform application of irrigation water. Pastures require a greater number of irrigations each season than do other crops. For this reason, it is particularly important that the land be properly prepared so that a minimum amount of labor will be required for irrigation. Once the land has been planted, very little can be done to improve the irrigation system without destroying the stand, releveling, and reseeding.

Pastures are irrigated by strip checks, contour checks, wild flooding, and sprinkling. Each method is discussed separately in this section. The method chosen will depend upon the type of soil, the available water supply, and the lay of the land.

Type of Soil. Fine-textured soils, or those underlain with a hardpan or clay layer, are preferred for irrigated pastures because water can be applied more efficiently, and because these soils hold more water near the surface where it is needed. Many large areas of heavy, shallow soils in California, which were once considered of no value for irrigated farming, are now used for irrigated pastures.

The amount of water which a soil can store for use by plants depends largely upon the size of the soil particles. The amount of readily available water which can be retained in a one-foot depth of soil, following an irrigation, is equivalent to about 1 inch of water in a sandy soil, 1½ to 2 inches in a loam soil, and 2 to 3 inches in most clay soils. These amounts can be taken only as a rough guide since some sandy soils can store more water for use by plants than can some clay soils.

It is necessary to apply only enough water, at each irrigation, to wet the soil to the depth of rooting. Most of the clovers and pasture grasses will root to a depth of only about 2 feet. Birdsfoot trefoil will root to a depth of 4 to 6 feet, alfalfa, to 6 feet or more. It is desirable to have alfalfa or other deep-rooted plants in the pasture mixture on porous soils to permit a more efficient use of the irrigation water.

Water does not penetrate into all types of soils at the same rate. Fine-textured soils (such as clays) and soils that are puddled take water slowly. Coarse-textured soils (such as sands) generally take water rapidly. It is difficult to irrigate sandy soils efficiently by surface irrigation methods because the water penetrates too deeply near the point of application.

Available Water Supply. When selecting a system of irrigation and when preparing the land, the farmer must consider the rate at which he will receive his water. Irrigation water is supplied from canals or wells. Where the supply is from canals, the farmer may receive his water as a continuous flow, on demand, or on a rotation basis. If the farmer owns his own pump, he can operate it to suit his needs.

The size of the stream of water which the farmer can obtain for irrigating his

Fig. 4.—Strip-checked land ready for seeding (Oakdale District, Stanislaus County). Note rolling nature of country and direction of strips. Checks are about 13 feet wide.

fields varies in different localities. It depends upon the source of supply, or upon the method of distribution in case the water is obtained from a canal.

Lay of the Land. Before the land is prepared for irrigation, it is desirable to have a topographic survey made of the field. A contour map, based on the survey, will show the direction and amount of slope, and the location of high and low spots in the field.

The amount of earth to be moved in preparing the land for irrigation can also be determined from the survey. This amount will vary on different farms, depending upon the unevenness of the ground surface. If there is only a shallow depth of topsoil, the depths of cuts should be kept at a minimum.

Final grades should be selected so that there will be a balance of cuts with fills. An allowance for shrinkage, generally about 10 per cent, is made when excavated soil is placed in fills.

An engineer or surveyor is usually hired to make the survey, to do the necessary computations for earth moving, and to select and lay out the irrigation system. The charge for this service is generally about $2 to $4 per acre.

Strip checks are the best method for smooth, gently sloping land and finer-textured soils; this method requires much land preparation

For the strip-check method of irrigation, low levees or borders are constructed at intervals across the field to guide the water as it moves down the slope (fig. 4, p. 9). This method has proved most successful on gently sloping lands which have a fine-textured soil that does not permit the water to penetrate too rapidly.

The width and length of the checks and the desired slope to use will depend upon the shape of the field, the topography, the amount of water available, and the type of soil. All of these factors must be properly balanced for each field.

On sandy soils with steep slopes, or on clay soils with only small flows of water available, it is sometimes desirable to have the checks as narrow as 8 feet. On heavy soils, where large flows of water are available and the land is nearly flat, the checks may be as wide as 30 to 40 feet. In a number of areas, farmers prefer to have the checks about 13 feet wide.

It is common practice to have the direction of the runs made so that the water moves down the steepest slope. This reduces the amount of cross-leveling that is required. If the field has a water penetration problem, this practice may not be desirable. Water penetration is generally increased when the slope is reduced. This can be accomplished by further land leveling or by altering the direction of the runs. If the land has considerable side fall, the strips should be made narrow. The difference in elevation between any two adjacent checks should not be over 0.2 foot.

The length of the strips will depend upon the shape of the field and the rate at which water penetrates the soil. In sandy soil, a great deal of water may be wasted by deep percolation at the upper ends of the runs if the strips are too long. This difficulty can sometimes be partly overcome by increasing the amount of water turned into each check.

Table 1 gives the recommended lengths of runs for checks of different widths and for various rates of flow. If the slopes are steep, strips longer than 800 feet should be limited in width to 15 feet or less. This table applies only to clay and clay loam soils. For porous loams and sandy loams, increase delivery rates for the sizes of checks given in the table from 2 to 5 times, or use shorter checks. This will permit the water to cover the ground quickly without too much being applied

Table 1

SIZES OF STRIP CHECKS FOR CLAY LOAM AND CLAY SOILS

Flow delivered to each strip		Length of check for various widths of strip			
		10 feet wide	15 feet wide	20 feet wide	25 feet wide
cu. ft. per sec.	gals. per min.	feet	feet	feet	feet
0.2	90	440	....	....	....
0.3	135	660	440	....	....
0.4	180	880	660	440	....
0.5	225	880	660	....	440
0.6	270	1,320	880	660	....
0.7	315	1,320	880	660	....
0.8	360	....	1,320	880	660
0.9	405	....	1,320	880	660
1.0	450	....	....	1,320	880
1.2	540	....	....	1,320	880
1.5	675	....	....	....	1,320

at any single irrigation. However, the velocity of the water should be kept sufficiently low to prevent erosion.

Strip checks require grade in only one direction—that in which the water flows down the check. This grade may or may not be uniform. Grades of 0.2 to 0.5 foot per 100 feet are desirable for covering the ground quickly. Steeper slopes are used in some districts where the soil resists erosion and where it would be inadvisable to level the fields.

Some farmers prefer to have the first 10 feet of the checks perfectly level so that the water will be uniformly distributed between the levees before it moves down the checks. To insure uniform coverage over the full width of the checks, the land between the borders must be carefully cross-leveled.

The unit head, which is the rate of delivery of water into each check, may vary from 0.2 to 1.0 cubic foot per second (90 to 450 gallons per minute). The unit head can be regulated by changing the number of checks irrigated at one time. The farmer has more control over this one factor than any of the other factors which make up his irrigation system. By experience, he will learn the size of stream to use to obtain the most efficient and uniform application of water.

Land Preparation. More land leveling is required for strip checks than for any other type of flood irrigation. The cost of a good job of land preparation is generally repaid, in future years, with dividends in reduced irrigation labor costs, savings on the amount of water used, and higher crop yields.

The first step in preparing the land for the strip-check method of irrigation is to do the necessary earth moving. The land should then be plowed or disked and the whole field smoothed with a float or land plane before the border levees are built (fig. 5). In land planing, it is best to level diagonally across the field first, then lengthwise across the field. Next, apply a special irrigation to settle the fills. After this, it is sometimes desirable to plow or disk and plane the field a second time.

Various types of equipment are used for constructing levees. Power machines, such as road graders or special, custom-built attachments for tractors which build the borders and level the ground between them in one operation, are used in some areas (fig. 6). Disk ridgers, crowders, or alfalfa checkers are also used, but with

Fig. 5.—Land planing is done after field has been rough-leveled, to insure that minor irregularities are eliminated. Careful leveling permits efficient use of irrigation water.

these, it is necessary to work the strip checks a second time to cross-level the land between the borders.

The size and the shape of the levees are important. They should have a base width of about 2 feet and a settled height of about 6 inches. Levees of this size will be covered with a growth of legumes and grasses, so that the entire field can be used for producing feed. When the levees are first constructed, they are composed of loose earth and are irregular in shape. Before being seeded, they should be compacted and smoothed. This can be done with some type of ringroller (fig. 10, p. 21) while the entire field is being rolled.

The lower ends of the border should be left open to drain off any excess water. Ponding at the lower ends of the runs drowns useful vegetation and encourages growth of undesirable, water loving types of weeds, such as curly dock and the sedges. Adequate drainage ditches should be built for collecting and removing surplus water from the low end of the field. In some districts, this surplus water is used to irrigate other fields; in other districts, it is dumped into main drainage ditches.

1948 Cost of Preparing Land. The total cost of preparing land for irrigation by the strip-check method will vary depending upon the amount of earth moving required. Rough leveling work can be done for 8 to 12 cents per cubic yard of earth moved. Leveling which requires that the land be left with a finished surface within 0.1 foot of the desired elevation will cost 14 to 20 cents per cubic yard. The cost for leveling the land may be as little as $20 or as much as $80 per acre. One large operator in Yolo County found that, during 1948, it cost about $30 per acre to level his land.

After the earth moving work, the soil is usually plowed and sometimes chiseled. The cost of chiseling will be about $1.50 per acre; plowing will cost slightly more.

The cost for land planing depends on how many times the machine has to go over the land (fig. 5). For once over, the cost will be between 50 cents and $1 per acre, depending upon the width of the blade and the efficiency of the operator. Most farmers plane their land two to four times.

Levees can be constructed for about $4 per acre. Harrowing and rolling the field after levee construction will cost about

Fig. 6.—Checking attachment for tractor. This machine builds the borders and levels the ground between them in one operation. Machine is equipped with leveling gauge.

$1 per acre. The cost of constructing head ditches will average between $1 and $1.25 per acre.

As of 1948, the total cost of preparing land for the strip-check method of irrigation, including the cost of the survey, varied from $30 to $130 per acre. If the land is fairly level, an average cost of about $50 per acre can be used for estimating purposes. If concrete pipe lines are used instead of open ditches, this cost will be increased by $60 to $150 per acre, depending upon the amount of water to be carried and the length of the irrigation runs.

Labor Costs. For irrigation by strip checks, labor costs per season vary with the total number of irrigations, the size of the stream to be distributed, and the length of time water is allowed to run at a single setting. Where water is furnished by an irrigation company or district, delivery is usually on a 24-hour basis and provision must be made for night irrigation. When water is supplied by private pump, lands are usually irrigated only in daylight hours.

With a large stream of water divided between a few checks of small area, water changes occur at frequent intervals, and close attention is required. Under such conditions, the irrigator must give his entire time to water deliveries. When small amounts of water are delivered to each strip, and the checks are large, the water is sometimes allowed to run for a long time and the irrigator may not devote all his time to water deliveries.

The average cost of irrigation labor on 24 farms in 1947, as shown by table 3, page 43, was $7.04 per acre for the season.

Turnout Structures. Gates for controlling the delivery of water from open ditches to the checks must be easy to operate and yet give close regulation of the water. The turnout gates are generally placed in the ditch bank at the center of each check.

Wooden field gates, such as are used in alfalfa irrigation, are sometimes used where the checks are large and big heads of water are necessary. For small, narrow checks, some form of slide gate attached to pipes passing through the ditch bank is generally used (fig. 7).

Concrete pipe lines are most useful where the topography is rough or where seepage loss from earth ditches is excessive. Pipe lines allow close control of the flow of water with a minimum amount of labor. Risers, in which orchard or alfalfa valves are installed, are placed at the head

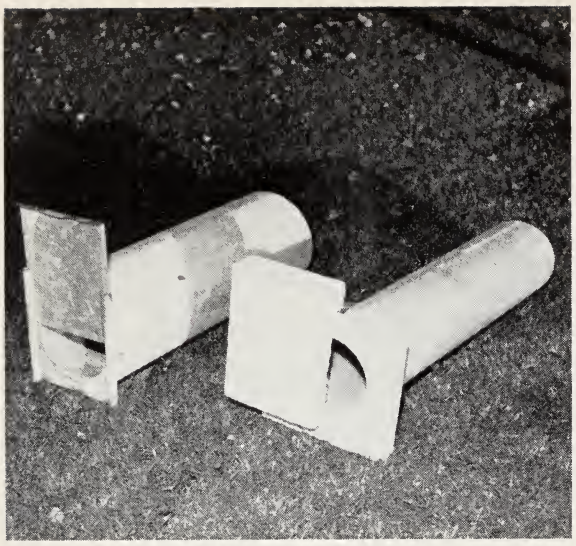

Fig. 7.—Types of turnout structures. These are placed in the irrigation supply ditch bank at the center of each check. Water flows through them from the ditch to irrigate the checks. The gates may be adjusted to regulate the flow of water.

of the levee beteen two checks. There should only be half as many risers as there are checks. Short sections of portable pipe are attached to irrigation hydrants placed over the risers during irrigation (fig. 8). The hydrants contain slide gates for regulating the distribution of water between the two checks.

Most erosion encountered with the strip-check method starts at the head of the checks because the water enters the check too fast. To cut down this fast moving water, the outlets should be placed slightly lower than the ground surface. The water will then be discharged into a pool. The outlets should never be placed so high that they permit the water to fall onto the ground surface.

Contour checks are good for flat lands. They cost less to prepare, and they have the lowest irrigation labor costs

Contour checks are irregular basins formed by small levees or ridges similar to those used in the irrigation of rice. This method is only suitable on heavy soils where the land is nearly flat or gently sloping. The contour-check method can be used to better advantage than can the strip-check method, on irregular-shaped fields. Large heads of water must be available so that the basins can be filled in a short time. Flows of 6 to 10 cubic feet per second are desirable.

If the land has previously been irrigated, the only land preparation required is to go over the field several times with a land plane. If new land is to be irrigated by the contour-check method, some rough land leveling may be needed.

Location of the contours is determined by use of the engineer's level and rod. Each levee is constructed on a contour, or line of equal elevation. The vertical interval between the bases of adjacent ridges is usually 0.2 foot. Where the land is so flat that very large areas would be enclosed by levees located on a 0.2-foot interval, the basins may be divided by cross levees or the vertical interval may be reduced. For irrigated pastures, it is not desirable to have more than 1 acre of land within each basin, although basins up to 4½ or 5 acres have been successfully irrigated. If the pasture is to be harvested for a seed crop, the levees should be at least 20 to 30 feet apart at their narrowest point.

The levees used in the contour-check method serve as a dam for the water. They must, therefore, be larger than those used for the strip-check method. A desirable size for the levees is a base width of 30 to 36 inches, and a height of 14 inches when new. The settled height should be at least 12 inches.

A broad, shallow ditch should be constructed down the slope through the approximate center of each check. Control gates are installed where the ditch passes through the levees. The ditch is used for rapidly draining the basins after they have been irrigated, and for carrying the water from the source of supply to the lower basins. In addition to the control gate on the ditch, ordinary stop gates are sometimes installed through the levee near both ends of the basin. The gates serve both as a check and as a spillway to keep the water from overtopping the levee.

The fields are irrigated from basin to basin, water being drained from the upper to lower basins, successively. Excess water from the last check is discharged to lower lands or to wasteways. Labor costs for irrigation by contour checks are lower than for any other system of irrigation, probably not exceeding $3 per acre per year.

The cost of leveling the land for contour irrigation will vary from practically nothing to as much as $50 per acre where considerable earth moving is required. Chiseling and planing the field will cost about $8 per acre. The cost of having the contours located by a surveyor, and of constructing the levees, will be between $2.50 and $4 per acre. Installing the gates in the levees will cost between $2.50 and $5 per acre. In general, the average cost of preparing land for contour irrigation will be about $30 per acre. This is about $20 per acre less than for strip-checks.

Fig. 8.—Irrigating two checks from single alfalfa-type valve with irrigation hydrant attached.

Wild flooding is used to a great extent in the Sierra foothills. It requires little earthwork, but it needs the irrigator's constant attention

The common method of irrigating pastures in the Sierra Nevada foothills is by spilling from ditches on flat grades, located on ridges and along the sides of the hills (fig. 9). The water is distributed from the ditches at selected points. It moves down the side of the hill to the next distribution ditch, spreading out over the area between on its journey downward. The irrigator must have considerable experience in irrigating a particular field by this method before he can apply the water evenly over the pasture.

Very little leveling work can be done because of the slopes and the shallow soils. Ditches, which are located on grades of 1½ to 2 inches per hundred feet, are built with a plow or with hand tools. Distances between ditches vary from 50 to 300 feet, depending upon topography. Delivery heads are small—from ½ to 1 cubic foot per second (20 to 40 California miner's inches). The few structures used are of simple design and easily built.

The water is generally purchased from canal companies in units of miner's inches, for the season, or for a 24-hour period. Two to four acres are irrigated from each seasonal miner's inch bought.

The amount of labor involved per acre in using this method of irrigation is greater than for the two methods previously described. Practically continuous attention is required by the irrigator while the water is running. Water is raised in the distribution ditch by building a dirt dam at the downstream edge of a section to be irrigated. The ditch bank is then opened at a number of places above the temporary stop. When the first section is watered, the operations are repeated for other sections along the ditch. An irrigator can water about 4 acres per day by this method.

Fig. 9.—Wild flooded irrigated pasture (Nevada County). Area in foreground is dry range. The ditch, plowed nearly on the contour, is broken at intervals to permit the water to seep down across the field to the next lower ditch.

Sprinkling is expensive, but it is good where the water costs are high and the land is hard to prepare for other methods of irrigation

Sprinkling is one of the newer methods of irrigating pastures. Even distribution and the possibility of controlling the amounts of water applied at each irrigation favor the use of this method for sections of high water cost, for pastures located on coarse-textured, easily penetrated soil, and for locations difficult or impossible to level.

There are three general types of sprinkler systems:

1. Underground main and lateral lines with rotating sprinklers in fixed locations. This system requires a large investment per acre. To reduce pipe costs, lateral lines should be as widely spaced as operating pressures will allow. With wide spacing, operating pressures must be high—usually from 40 to 50 pounds per square inch at the pump. Although first cost and power costs are high for this type of system, labor charges are very low.

2. Underground or portable main lines with portable lateral lines equipped with rotating sprinklers. First cost is lower for this type of system than for (1); operating pressures are the same; but labor charges for moving the laterals add considerably to the total cost of operation. Time out for moving the lines reduces the percentage of total time the sprinklers can be operated. In irrigating other crops, studies showed that twenty-five systems using two distributing lines operated 85 per cent of the time, while thirteen single-line systems operated only 67 per cent of total irrigation time.

3. Portable surface-pipe main lines with the end sections perforated for spray irrigation. This system is cheaper in first cost than either (1) or (2), and will operate on pressures as low as 8 to 10 pounds per square inch. A strip from 30 to 35 feet wide and as long as the perforated section of the pipe is wetted at each setting. Rates of application by this method are high, the lowest rate being about 1 inch in depth per hour for the area covered. For an application of 2 inches in depth the line would have to be moved every 2 hours. Power costs are low for this system, but labor charges are high.

In general, the high cost limits sprinkling to small areas which cannot be irrigated by other methods. (California Experiment Station Circular 388 discusses sprinkler irrigation in detail.)

Main costs are for water and labor. Water used depends on temperature, length of season, depth of wetting, plant types, system, and layout

How to figure amounts of water. As a means of checking up on irrigation practices, the depth of water applied to any field in a given time by a given flow may be easily figured by using the following approximate formulas:

$$1.\quad \frac{\text{Flow in cubic feet per second} \times \text{hours run}}{\text{Number of acres irrigated}} = \text{Inches depth applied}$$

Example: Area, 40 acres
Flow, 8 cubic feet per second
Time to irrigate, 15 hours

$$\frac{8 \times 15}{40} = \frac{120}{40} = 3 \text{ inches deep}$$

$$2.\ \frac{\text{Flow in gallons per minute} \times \text{hours run}}{450 \times \text{number of acres irrigated}} = \text{Inches depth applied}$$

Example: Area, 25 acres
Flow, 900 gallons per minute
Time to irrigate, 40 hours

$$\frac{900 \times 40}{450 \times 25} = \frac{2 \times 8}{5} = 3.2 \text{ inches deep}$$

With these formulas, the irrigator can find out the efficiency of any particular layout. Such calculations may show a need for changes in operation or layout.

Use of water. The total amount of water used will depend on temperature, length of growing season, frequency of application, depth of wetting, and to some extent on plant types, irrigation method, and layout. In northern counties the short growing season limits total use, while in coastal regions the lower temperatures reduce the rate at which plants give off water. The high summer temperatures and long growing season of the interior valleys require greater use of water.

Water applied at each irrigation is always more than that given off by plants, and under some conditions this excess is considerable. Each time the pasture is irrigated, a portion of the water applied is lost by surface evaporation—the more frequent the applications, the more water lost. The amount of water applied and the soil texture determine the depth of wetting. Coarse texture tends to increase water application both at a single irrigation and for the season. Difficulty in wetting soils evenly to the depth of the roots results in the application of too much water. In some cases runoff water is discharged to wasteways.

On coarse-textured soils in the interior valleys, it is often necessary to irrigate every week. Observations show that the number of irrigations during the season may range from 15 to more than 20, with a total use of 6 to 10 acre-feet. On deep, porous loams and silt loams at the University Farm at Davis, irrigations were at 10-day intervals and the water use for the season was 5 to 6 acre-feet. Actual measurements of water on pastures on shallow clay loams in the Sierra foothills of Nevada County showed a total annual use of 2¾ to 3 acre-feet applied in 12 irrigations. The length of the irrigation season was 6 months. On heavy Madera clays in Merced County, approximately 3 acre-feet of water was used during the season, applications being at 12-day intervals.

While it is difficult to estimate beforehand the total water use of pasture crops and the frequency of application, it would appear that a total use of 5 acre-feet applied in 15 irrigations is a satisfactory basis for planning the enterprise.

Cost of water. The principal cash costs of irrigated pastures are for water and for irrigation labor. Labor costs are discussed under the various methods of irrigation.

Water is supplied by irrigation enterprises and by private pumping. The various enterprises usually deliver gravity water and the cost varies considerably. While in some sections the cost may be less than $2 per acre per year, the annual charge for the majority varies from $3 to $5, with higher costs of $8 to $10 in other areas. Under most of the gravity systems, water costs are on an acreage basis and water is not measured carefully. Certain systems may not be able to furnish late-season water, in which case private pumping is required.

The cost of pumping varies with the type of power used, the total pumping head, over-all efficiency, and total use of the plant. The costs indicated below are for electric power alone, the overhead be-

Table 2

COST OF ELECTRIC POWER

Lift from well	Lift above ground and pipe friction	Total pumping head	Use per acre per year	Acre-feet × pumping head	Power costs per acre
feet	feet	feet	acre-feet	acre-feet-feet	dollars
60	0	60	3	180	3.60
60	30	90	3	270	5.40
60	0	60	5	300	6.00
60	30	90	5	450	9.00
60	0	60	7	420	8.40
60	30	90	7	630	12.60

ing considered as part of the general overhead expenses of the farm enterprise.

With an over-all plant efficiency of 60 per cent, an estimated use of 5 acre-feet per acre per season, and a pumping capacity of 1 cubic foot per second for 40 or more acres, power costs, under commercial rates, will approximate 2 cents per acre-foot per foot of lift. If overhead costs on pumping are considered separately, an additional allowance of 1.8 cents per acre-foot per foot of lift should be made. Table 2 shows the cost of electric power for various pumping heads and various amounts of water.

An average cost of water of $8 per acre per year is a fair figure for use in planning an irrigated-pasture enterprise.

Seedbed Preparation and Planting

Seedbeds should be firm—usually preirrigated.
Seed may be broadcast or sown by drill.
Planting should be done in fall or early winter.

A seedbed satisfactory for seeding alfalfa is adequate for an irrigated pasture. Such a seedbed has a firm, moist bottom covered by 2 to 3 inches of moist, well-worked soil free from big clods and large air pockets. A loose, cloddy seedbed filled with air pockets may result in a patchy, poor stand. Wetting the soil before planting is important because: (1) it settles the fills and reveals potholes and other irregularities that can be corrected before seeding; (2) it firms the soil for seeding; (3) it provides an even and dependable moisture supply for germinating the seed. It is not always essential to preirrigate, however, if there has been enough rainfall just before seeding. After the irrigation or rain, the field should be replaned (see page 12) if irregular settling has occurred. Levees will then have to be rebuilt (where strip-check or contour-basin irrigation is to be used). A final harrowing should be given the field just before it is seeded. If the soil is still loose and open after the planing and harrowing, the field should be rolled with a ringroller to firm it.

Time of seeding recommendations do not vary greatly in the counties. Fall seeding is most common. In northern counties at higher elevations, spring seeding is used to some extent. In Shasta County, October 1 to November 15 seeding is recommended; in Riverside County, October, November, or February; in Madera County, December to February; and

in Orange County, early December or early March. All of the varieties commonly used in an irrigated-pasture mixture will germinate and grow in the fall, except Dallisgrass and Rhodesgrass, and these will usually remain dormant for a spring germination to a sufficient stand. Fall and winter temperatures and moisture conditions are generally more favorable for continuous and adequate soil moisture until the young plants are so well established that irrigation can be applied without danger of washing. Soils with a tendency to form a surface crust are less likely to do so in the fall. Winter temperatures, however, are likely to be fatal to sprouting plants in the northern and colder parts of the state, hence the practice of spring seeding in those areas. Seeding in the heat of summer rarely gives best results.

Seeding methods by ground equipment vary widely in different parts of the state and among individual producers. Some plant the grass and clover seeds separately, others mix and sow them together. The claim that clover seeds settle to the bottom in a mixture is not generally true when the seeding is done by hand. If a mechanical broadcast seeder or drill is used, the grass and clover seeds should be planted separately since they will not distribute evenly through ordinary seeding equipment. Any method that will give an even distribution of all species is satisfactory. Three types of ground equipment are being used for mechanical seeding of pastures: (1) an endgate broadcast-seeder mounted on the bed of a truck or wagon; (2) grain drills with special grass seeding attachments; (3) a new type combination broadcast-seeder and ringroller (fig. 10).

Airplane seeding appears to be increasing, especially in areas where the size of the fields is large enough to justify this method. As with ground equipment, it is usually necessary to seed the legumes separately from the grasses. Special seeding attachments for airplanes are necessary to handle the small-seeded legume species, such as Ladino clover and alfalfa. The seeding rate of the legumes, with standard grain seeders, will probably be much too high. Present costs of plane seeding vary between $1 and $2 per acre (including two times over). The cost of ground-rig seeding (which also usually requires two times over) in some instances is less than this. On a calm day, a careful flyer can uniformly distribute seed on 300–500 acres. In seeding the legumes separately, he must be particularly careful to lap the seedings, otherwise the field will be strip-seeded to legumes. Some plane operators are now seeding both the legumes and grasses in a complete mixture in a single flight. Whether the seeding can be done in one flight only depends upon the operator and his equipment. The best plan is to secure an experienced operator and let him apply the seed as he wishes. The pasture owner should make it clear to the operator that he requires a uniform seeding of both legumes and grasses. Since the costs per acre for ground and plane seedings are fairly close, the principal advantage to plane seeding seems to be the speed with which the job can be accomplished. The pasture owner can get the seed on while the seedbed is in prime shape. If seeding should be delayed by rains after the field has been prepared, a plane can be used when ground equipment cannot get into the wet field.

Seed shallow, not over ½ inch deep in most soils if a grain drill is used to plant. Subsequent operations should not bury the seed deeper.

Ringrolling or harrowing should immediately follow seeding, whether the seedings are by the broadcast or drill method. Experience has shown that ringrolling (fig. 10) presses sufficient soil over and about the seed to insure good germination. It further insures the firm seedbed required by germinating grass and legume plants. If only harrowing is used, it should be light.

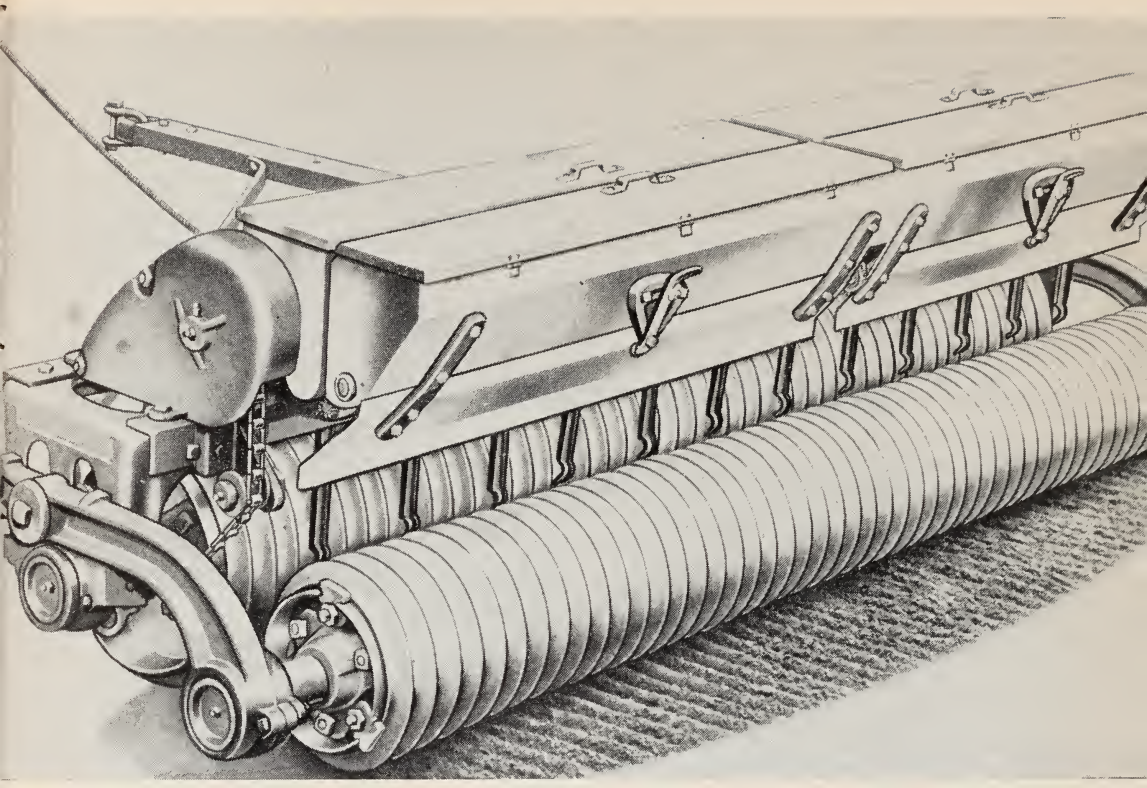

Fig. 10.—New type commercial pasture seeder—actually a ringroller with a seeding attachment. A ringroller firms seedbeds and presses the soil about the seeds after planting.

Seeding rates vary rather markedly in the various counties (pages 50–57). In general, heavier rates of seeding prevail in the southern part of the state for reasons shown (page 23). Lesser fluctuations among adjoining counties are doubtless due to differences in prevailing methods of land preparation and in methods of seeding. If a seedbed is in prime condition and moisture is adequate, experience has shown that 12 pounds of seed per acre will eventually produce as good a stand of plants as will 24 pounds.

With the "standard" mixture given on page 22, the 14 pounds of seed, if evenly distributed over an acre of land, would give the following number of seeds per square foot: Ladino, 49; annual ryegrass, 10; perennial ryegrass, 15; orchardgrass, 40; tall fescue, 21; a total of 135. A good stand will be obtained if less than 10 per cent of these develop strong plants on a square foot of soil. Liberal allowances should be made for wastage and loss, but it is uneconomic to use seed extravagantly.

Proportionate amounts of the ryegrasses have been reduced markedly in recommendations and in current practice since this circular was first issued. Experience has shown that these quick-starting grasses tend to shade out the seedlings of other perennials that start more slowly. The population of ryegrasses can be increased at any time in the life of a pasture by oversowing in the winter or early spring.

Seed costs (unless excessive amounts per acre are used) represent a small part of the investment in pasture development, and every grower can and should use the best available. Low-cost seed isn't always the most economical seed. Irrigated pastures are primarily a long-time crop, and

it is important that all of the seeds in the mixture be of top quality, even if the cost per pound is somewhat high.

The use of certified seed, when available, will assure the grower that he is getting the best, with maximum purity and freedom from weed seeds. Further, he is assured of getting the exact strains and varieties he wishes to use. This is particularly important with new strains and varieties of forage plants coming on to the market. Common seed is usually a mixture of common and less productive strains. Certified seed of the improved varieties is carefully produced and inspected to insure that it is true to type, free of disease, and free of noxious weed seeds.

General- and Special-Purpose Mixtures

The two main types of legume and grass mixtures are general-purpose, and those which are used for special soil conditions

Beginning on page 50 is a list, by counties, of general-purpose and special-purpose mixtures recommended by local farm advisors. These recommendations are based on extensive local observations and results secured in local tests. The special mixtures are suggested for particular climatic, soil, and topographic conditions.

The following mixture, however, might be considered as standard, in terms of pounds of seed per acre, in any area to which all are adapted. (Alfalfa, birdsfoot trefoil, and Dallisgrass, optional.)

Ladino	3
Domestic ryegrass	2
Perennial ryegrass	2
Orchardgrass	3
Tall fescue	4
Total	14

For assistance on situations not included in the list (pages 50–57), consult your local farm advisor. These agricultural specialists have developed pasture mixtures especially compounded to fit local situations—for example, areas affected by the molybdenum problem.

Molybdenum toxicity in cattle. Since about 1869, a cattle disease characterized by diarrhea, breeding difficulties, and change of coat color has occurred in some areas of the state, including the San Joaquin Valley. Recent research by the University of California has shown that the disease is caused by an excessive amount of molybdenum in the pasture plants. Certain districts of Fresno, Kings, Kern, Santa Barbara, and Riverside counties are involved. Sheep are, reportedly, rarely affected; horses and hogs have never been reported as being affected. In these special areas, research has shown that the legumes, such as birdsfoot trefoil and Ladino clover, are usually much higher in molybdenum content than are the grasses. However, among the legumes, alfalfa is the lowest in molybdenum.

Acting on this information, local farm advisors have recommended pasture mixtures which avoid legumes known to take up large amounts of molybdenum. For example, the Kern County farm advisor recommends no legumes at all in the pasture mixture where the problem is acute. In Kern County areas moderately affected, alfalfa is the only legume recommended in the mixture, as follows: Alfalfa, 2 lbs.; Dallisgrass, 3 lbs.; annual ryegrass, 2 lbs.; perennial ryegrass, 2 lbs.; Rhodesgrass, 2 lbs.; tall fescue, 8 lbs.; total, 20 lbs. per acre.

Although the right kind of pasture mixture will help in reducing molybdenum

injury, other pasture and livestock management factors can also be used. For example, during the first season, the initial two or three crops on an irrigated pasture should be cut for hay rather than being grazed. Heavy and less frequent irrigations have assisted in some districts. Rotational grazing, so as to graze only older growth, has generally aided. Feeding of straw or access to range feed will tend to relieve the severe diarrhea symptoms. For more complete information on this problem, the grazier should consult his local farm advisor. Investigations are proceeding which will undoubtedly yield more information on methods of preventing molybdenum poisoning on irrigated pastures. In case difficulty develops with stock, consult your local veterinarian.

Recommendations in the list show several interesting trends:

1. In the southern part of the state, a larger poundage of seed and a greater number of species are used. This is probably because more species are needed to produce growth through the longer pasture season in that area.

2. Bur clover or black medic is generally included in the mixture for the southern counties because these plants grow during the winter months and provide a legume at that time.

3. A light seeding of alfalfa is generally advised in the San Joaquin Valley and, to a lesser degree, in other warm areas. This is to provide a legume during the hotter months when there is a sag in the growth of Ladino clover.

4. Recommended mixtures usually have a number of different species in them to take advantage of their seasonal difference in growth habit. While most of the perennial grasses may be kept green throughout much of the grazing season by pasturing and irrigation, they do have a preferred season for growth and ripening. Annual ryegrass is the earliest we now have in growth and natural maturity. It tends to become semidormant, even under irrigation, by midsummer. Perennial ryegrass is somewhat later and more persistent in growth habit. Orchardgrass, meadow fescue, and Dallisgrass are midseason grasses, while redtop and timothy are late. Tall fescue is a midseason grass which grows well into the fall. Harding is the latest of all and, in the warmer sections, is practically winter-growing.

5. Seed mixtures are based not only upon climatic and soil conditions, but also upon kind of livestock which will use the pastures. Cattle and sheep require a different type of pasturage from hogs. Horses do best on still another kind.

With cattle and sheep, bloat hazard must be considered as well as grazing preferences. When the mixture is mostly grasses, the animals tend to crop the legumes closely. When the pasture is largely legumes, they search for grasses and the coarser material. From 40 to 50 per cent legumes has been found to meet the grazing preference of cattle and sheep with a minimum of bloat hazard.

For hog pasture alone, legumes, such as Ladino clover or alfalfa, are best. Hogs will eat a limited amount of succulent grasses, but their needs are best met by legume forage. Grasses in the mixture will be neglected, become coarse and woody, and the grazing capacity of the pasture will be lowered. A legume pasture should only be used for hogs, since the bloat hazard on a straight legume pasture is very high for cattle and sheep.

Horses, on the other hand, prefer rather coarse, stemmy grasses for most of their grazing ration. From 10 to 20 per cent legumes meets their requirements, although such a low percentage will hardly maintain maximum forage yields unless heavy applications of nitrogen fertilizers are made.

Goats which are grazed do best on the type of pasture discussed above for cattle and sheep. Feeding management of milking goats on pasture is very similar to that for dairy cattle.

Pasture Management

Pasture management includes: getting the best feed value; grazing rotation; supplemental feeding; clipping; harrowing; fertilizing; weed control

The three chief objectives of a pasture operator should be (1) to maintain an adequate stand and balance of desired species throughout the pasture season, (2) to obtain and continue the highest possible grazing capacity, and (3) to use the pasture plants when they are most nutritious.

It will not generally be possible for a grazier to determine the full success of his seeding or the average composition of his stand during the first year after seeding. Most of the perennial grasses used do not develop fully until the second or third year. Some of the seeds may lie dormant for a considerable time awaiting favorable soil temperature or moisture conditions. Ladino clover usually contains a rather high percentage of hard seeds, which will not germinate until the seed coat has been softened by long contact with moisture. Many seedings that have appeared as failures the first year have developed into satisfactory stands and good mixtures.

One of the reasons for using some ryegrass is that it germinates and grows rapidly and provides much of the forage during the first pasture season. A new pasture may be grazed without injury to it when the ryegrass in the mixture is 6 to 8 inches high. However, the stock should be on it only while actually grazing; it should not be pastured too close; and no stock should be on the field while the soil is wet.

The efficient use of irrigation water and proper grazing rotation contribute more to successful pasture operations than any other items. Irrigation facilities, layouts, and practices are discussed in an earlier section (page 8). Since water is generally the most expensive single item, its proper use without waste is doubly important in economic pasture practices.

Obtaining the best feed value from a pasture. The following tabulation shows the variation in the protein content of some plants at different stages of maturity:

PLANT AND STAGE	Digestible protein, on the basis of 15 per cent moisture
Alfalfa:	
Immature	17.0
After bloom	5.4
Kentucky bluegress:	
Before heading	15.0
After bloom	2.7
Orchardgrass:	
Before heading	13.0
After heading	4.9
Timothy:	
Pasture stage	13.9
In seed	2.2
Mixed grasses:	
Immature	10.3
At haying stage	4.7
Mixed grasses and clover (closely pastured)	13.0

Fig. 11.—A good layout for rotation grazing. Under this system, water and salt are accessible to any one paddock from a single small corral. Gates are used to close off pastures not being grazed. Above: (1) pasture now being grazed (note cattle in corral for water); (2) and (3) pastures recovering from recent grazing; (4) pasture nearly ready for grazing.

From this tabulation it is evident that animals on a good pasture of immature grasses and clover receive a liberal supply of protein, which is usually the most costly part of livestock ration. Immature pasturage also provides a better supply of vitamins, particularly carotene, from which vitamin A is made in the animal body. With dairy stock, this results in a higher vitamin-A content in milk. In addition, such pasture is usually about twice as rich in phosphates as mature, freshly cured grass.

While it is true that livestock derive the most feed value from plants before the seed has matured, it must also be remembered that plants cannot survive in full vigor unless allowed to mature enough to nourish themselves. There is no exact rule that can be applied to all plants at the same time, with regard to when the best feed value can be obtained. In general, when a plant starts to flower, it will have stored enough nourishment so that its top may be grazed or clipped without reducing its vitality.

Grazing rotation. Rotation of livestock should be timed to fit in with irrigations. A pasture should not be grazed while wet. This causes permanent damage to soil and plants by compaction and trampling. Irrigations are from 7 to 12 days apart, in the interior valleys. During the spring and summer, it takes from 10 to 21 days for a Ladino clover-grass pasture to recover from a close grazing—considerably longer in the fall months (page 24). The number of pasture subdivisions or paddocks required will depend upon the individual setup. From 3 to 8 subdivisions are commonly used. With a pasture divided into 3 sections, each paddock could be grazed for 7 days with a 14-day resting period between grazings. During this recovery period, 2 or 3 irrigations could easily be applied.

Objections to certain grasses have arisen through faulty grazing management. Dallisgrass, for example, starts rather late in the spring, but is a rapid and persistent grower throughout the summer and develops seed heads in rather short intervals after grazing. Once it has formed seeds, the stock avoid it; thus in some pastures there are many matured plants of Dallis, while the other species

Fig. 12.—Electric fences are an economical means of subdividing pastures for rotation grazing.

have been grazed more closely and evenly. In fields where Dallis (or any other species) takes the lead at some time during the season, the rotation period should be shortened so that the pasturage is cropped when it is most nutritious and palatable. It may also need heavier stocking or mowing. In some pastures, orchardgrass is not looked upon with favor because it tends to form coarse tufts or tussocks. An even mixture of any of these bunch grasses with Ladino clover or trefoil can only be insured by a rotation planned to keep them from getting too mature. And any rotation that is adequate must be flexible so that it can be adjusted to meet the growth habits of all the plants in the mixture.

In general, rather close and prolonged cropping tends to increase the clovers at the expense of grasses, while infrequent and insufficient grazing tends to produce more grasses than clover. A good rule-of-thumb which seems to be reasonably satisfactory is to put livestock on a pasture when the Ladino clover begins to show considerable bloom. But no definite rule can be given to cover all pasture plants, all sites, and all seasons. Maximum feed values and carrying capacity will usually be obtained when enough animals are turned in to crop the growth moderately close and evenly in a rather short time (3 to 6 days). Where high-producing dairy cows are concerned, it may be advisable to give the last part of each rotation over to young or dry cows.

Wise pasture management is necessary throughout the growing season. If soil, climate, and moisture are favorable, a plant's ability to compete with others in the mixture will depend on its height and the thickness of its foliage at maturity. By these standards, orchardgrass is more aggressive than annual ryegrass, and much more so than perennial ryegrass and Ladino clover. Thus if the early species in the mixture are allowed to reach full maturity—or even full height—they tend to weaken and choke out the species which normally come on later. Some plants with runners or rhizomes, such as Kentucky bluegrass and Bermudagrass, have creeping habits which help them form a sod and thus resist crowding by other species. Proper pasture management, therefore, depends upon keeping down the more aggressive species when their growth is strongest, by grazing or mowing. This will maintain a good mixture and a long pasture season.

Fig. 13.—Creep feeding beef calves on pasture. Fencing excludes cows, but openings are large enough for calves to get into area where self feeders are located.

A set rotation scheme eliminates fluctuations in the quality of feed. A moderately mature paddock should be pastured off in 3 to 6 days and the stock moved on to the next one. It has been repeatedly shown that the very young leaves of plants are more succulent, or watery, and less nourishing than those which are more mature. On immature pastures, grazing animals tend to overgraze to satisfy their needs. Where the pasturage is more mature and nutritious, however, the animals' needs are better satisfied without such close grazing. To insure even and adequate nutrition, therefore, the operator should adjust irrigation and grazing rotations so that livestock will be on as nearly uniform feed as possible.

Overgrazing reduces profits because it lowers feed production and tends to accentuate livestock parasite difficulties. At the end of a rotation grazing period, there should be from 4 to 6 inches of even plant growth over the pasture. During the growing season, this reserve makes possible a very rapid recovery after grazing. If pasture is eaten into the ground continuously, recovery is slower and total production of forage and livestock products is very much lower. A Tehama County Extension Service coöperator nearly doubled his pounds of gain of lamb by converting from a continuously close cropping program to a rotation system. Now he never crops his pasture closer than about 6 inches, and he follows a set rotation scheme.

Recent research at the College of Agriculture has shown that the bulk of livestock internal parasites living in pastures is near the ground level. It has been found that the plant growth 6 to 8 inches high and higher is comparatively free of these parasites. Therefore, a grazier can reduce his parasite-control problem by not grazing his pastures too closely.

Supplemental Feeding of Meat Animals.[1] Extensive observations and a number of tests with cattle and sheep have clearly established the advisability of having dry roughage always available to stock on irrigated pasture. Preferably, it should be fed in bunkers or racks, but some graziers feed it loose on the ground. Any kind of dry hay can be used, and ordinary grain straw will meet this requirement very well. It should be chopped

[1] This section was contributed by Horace T. Strong, Extension Specialist in Animal Husbandry, Berkeley.

Fig. 14.—Feeding corral and calf creep feeder on irrigated pasture. Stock work back and forth at will from pasture to corral for supplemental grain and hay.

for sheep. Mature beef and dairy cattle on irrigated pasture will consume from 1,000 to 2,000 pounds of dry roughage per head during a pasture season of nine months. Dry roughage provided in this way reduces the danger of bloat (see page 29), adds variety to the ration, and also supplies additional dry matter to meet the daily nutritive requirements of the pasturing animals. Succulent green forage from irrigated pastures alone is often too low in percentage of dry matter for proper nutrition.

Only a limited number of field trials have been conducted in this state on the supplemental feeding of grain and other concentrates to meat animals on irrigated pasture. The practice of finishing beef cattle on irrigated pastures is spreading. Lambs appear to make satisfactory gains on good irrigated pasture with no other supplement than dry roughage.

Records recently kept by the Agricultural Extension Service on two ranches in Monterey County indicate that two-year-old steers can be economically finished on irrigated pasture when supplemented with about three pounds of rolled barley and four pounds of grain hay per head, per day. Gains from pasture and supplements totaled 640 pounds of beef per acre of pasture fed. One of the ranches with a large group of cows and calves produced 869 pounds of gain per acre of pasture per season when the pasturing stock was supplemented with barley and barley hay.

The extent to which grain may profitably be fed to cattle on pasture will depend to a large measure upon the individual ranch setup and current price relationships. The quality and class of cattle available, age of cattle and market demand, as well as the quality of the pasture itself, are factors which necessarily must be considered. The farmer has a choice of four possible methods in fattening cattle for market: (1) finish on pasture with no supplemental feed other than a minimum of dry roughage; (2) give supplemental full feed of grain and hay during entire pasture feeding period, finishing on pasture; (3) give supplemental full feed of grain and hay for the last 60 to 90 days on pasture; (4) finish cattle on full feed in the dry lot following the pasture feeding period. There is need for additional trials which will provide growers with more experience and information on this subject.

There appears to be considerable opportunity in this general field.

Numerous tests have shown that hogs make the most economical gains when self-fed grain on pasture. In most cases, the pasturage provided is nearly 100 per cent legumes, such as Ladino or alfalfa.

Reducing the Bloat Hazard.[2] Bloat is a hazard when cattle and sheep are grazed on pastures high in legumes, such as clovers or immature alfalfa. Birdsfoot trefoil is not troublesome in this regard. The accumulation of gas in the first two stomachs of ruminants occurs, not because of excessive gas formation, but rather because there is an interference with the normal mechanism of gas elimination when ruminant animals eat clover or immature alfalfa exclusively. Belching, the usual means of getting rid of gas in cattle and sheep, appears to depend upon the presence of coarse, irritating roughage in the first stomach. The leaves of grasses have barbed edges, and the stems, harsh fibers which stimulate belching. Leaves of legumes, such as alfalfa and Ladino, are smooth and do not stimulate belching.

There are several methods of preventing bloat:

1. Mix grasses with legumes. Practical experience indicates that bloat rarely occurs if grasses make up at least 50 per cent of the mixture. One must bear in mind that the proportion of grasses to legumes may vary with the season. In alfalfa mixtures, the percentage of grasses may decline in the summer to the point where it will be imperative to supplement the pasture with dry roughage to prevent serious bloat losses. A similar situation may prevail in Ladino mixtures in the early spring.

2. Feed dry roughage. Dry hay or straw may be fed in drylot, but preferably it should be fed in the pasture. Experience with milking dairy cows has shown that bloat may be completely prevented on alfalfa pasture by feeding cows all the Sudan hay they will consume overnight and then turning them onto alfalfa during the day. Feeding of dry Sudan hay in the pasture has likewise proved effective. Alfalfa hay or barley straw is less effective, but still of definite value. Oat or barley hay should be fully as effective as alfalfa hay.

3. Alternate Sudan and legume pasture. It has been found that if milking cows are pastured on green Sudangrass overnight, bloat is usually prevented when they are placed on alfalfa pasture the following day. Pure Sudan pasture is very palatable, and the writer believes that its use in conjunction with alfalfa and Ladino pastures should be encouraged. It is likely that in addition to preventing bloat, such an alternate system of pasturing may actually improve the nutrition and productivity of the animals involved. Moreover, with more pasture operators practicing crop rotation, Sudangrass can be nicely fitted into the crop rotation scheme.

4. Pasture alfalfa in the bloom stage. Under most conditions, bloat is not troublesome if alfalfa is allowed to reach the early bloom stage (10 to 25 per cent bloom) before pasturing. If, under this condition, there is still difficulty with bloat, cutting strips of the pasture as illustrated in figure 16 is advised. (Note that the animals are concentrated in the cut strips.) Just why animals prefer mown alfalfa to standing alfalfa we do not know. But because they do, they automatically prevent or reduce bloat by consuming the coarse stems with the succulent tips. Dairymen have recognized for many years that if green alfalfa is cut and fed in drylot, bloat rarely occurs. Allowing the cows to eat the cut alfalfa in the field, as is suggested, will save labor. Furthermore, clipping the pastures is helpful in weed control.

[2] This section was contributed by Dr. H. H. Cole of the Division of Animal Husbandry, Davis.

Fig. 15. — Coarse, ungrazed clumps around cattle droppings. These can be reduced by mowing and harrowing.

Mowing. If the livestock numbers on any given farm are properly balanced with year-round feed supplies, there will probably be an excess of pasture during the spring months of flushest growth. At this time hay supplies may be considerably increased by so adjusting the rotation that each paddock may be mowed at least once (fig. 11, p. 25). This practice also has other benefits. It is one means of controlling the growth of weedy plants and of reducing the coarse growth that has accumulated around cattle droppings (fig. 15). Even in fields that are being pastured, occasional mowing is a beneficial practice in reducing weeds and promoting even cropping and full utilization. If the hay is not needed, it may be placed in windrows on the levees. Stock will subsequently clean it up with great relish as they pasture the green feed.

Harrowing. Harrowing of pasture to spread the droppings of cattle has long been a regular practice in most foreign countries. Authorities have calculated that the droppings of a herd of 30 cows, if fully utilized, have the following annual fertilizer values: 9 tons of sulfate of ammonia, 2¼ tons of superphosphate, 4½ tons of potassium. On the other hand, unscattered droppings of 30 cows would mean a loss in potential grazing areas in and around the droppings equal to 4½ acres a year. Plans for making the flexible loose-ring harrow shown in figure 18, are obtainable from any farm advisor. This is listed as B 502-1 on the University's list of farm-building plans.

A flexible type harrow (fig. 18, p. 33) does a better job of breaking up and spreading cattle droppings than does the rigid type. Some graziers are using sections of war-surplus steel matting (for temporary air strips) as pasture harrows. Harrowing is especially effective after a rain or irrigation, when the droppings may be easily broken up and spread.

Fertilizing. It is too frequently assumed that pasturing livestock return enough manurial material to the soil to

Fig. 16.—Pasture mowing helps control bloat and weeds, and aids in developing a uniform stand. Note cattle seeking dry feed on mown strip.

maintain maximum yields. This is not true. Much of the soil fertility is converted into milk, meat, or wool, and thus is permanently removed.

Because Ladino clover and some of the grasses used with it are shallow-rooted, a high percentage of their food is taken from the first foot of soil. This puts a heavy drain on soil resources, and may eventually result in decreased plant vigor. In some California soils, this has not occurred in fifteen or more years of pasture use. In others, however, it may occur in a much shorter interval, while still others always require fertilizers for maximum production.

Need of fertilizer can best be determined by plot tests to show plant responses on each site, and such tests should always be made in any system of adequate pasture management. Fertilizer practices should be based on results of these tests.

It is difficult to measure plant responses on an area that is being pastured. Some experience also shows that on some soils, repeated fertilizer applications are essential to produce significant results. Where first responses are uncertain, it may be good practice to apply the same fertilizer element to identical small test areas each year for a period of three to five years before attempting to reach conclusions.

Some soils fail to respond to any known element of plant food. This may mean that no fertilizer is needed. If, however, such soil is not producing properly, it would be well to continue a fertilizer testing program.

Nitrogen, phosphorus, potassium, lime, sulfur, or some micronutrient element (an element necessary to plant growth, but in very small amounts) may be deficient when production is not adequate or begins to decline at some time in the life of the stand. Plot tests are useful in finding out these facts. On many soils, legumes respond to phosphorus, and grasses to nitrogen (fig. 17). On some soils a good growth of Ladino cannot be economically attained, apparently because of inadequate supplies of phosphorus; and added phosphorus may be fixed in these soils so rapidly that it is not available to the plants.

In addition to maintaining general production, fertilization may be a valuable aid in maintaining the balance of legumes and grasses. Thus if the legume is deficient, it may be stimulated by the addition

Fig. 17.—Foreground, fertilized with phosphate—stimulates clover; background, fertilized with nitrogen—stimulates grasses.

of phosphorus (or sulfur or some other element to which it has shown a response). If the grasses are low, they can almost always be stimulated by the addition of nitrogen.

There is perhaps no fixed time to apply fertilizers. Usually applications in the spring (January to March) seem to produce the best results. In the older pasture districts, it has generally been found that annual top-dressings in amounts known to be adequate for plant needs for the season are preferable to larger amounts applied at two- to five-year intervals. A recent survey showed that some graziers are applying fertilizers twice a year, in February or March and in July or August. This tends to prolong the season of pasturage and to promote plant growth in midsummer and fall as well as in the spring.

California dairymen are rapidly installing liquid manure pits and pumps so that corral and barn manure can be returned to the pastures. In some cases, it is being returned in liquid form through the irrigation system. Pastures respond remarkably well to application of animal manure.

Control of weeds. Besides the weedy species already discussed, there are many other undesirable species that are invading irrigated pastures to such an extent as to greatly reduce the carrying capacity.

The presence of certain sedges and swamp grasses is usually a sign of faulty land preparation and irrigation practice, since these species thrive in lands too wet for ideal pasture-plant responses. Such plants as dock should be promptly attacked as soon as they appear, and should be removed by pulling or grubbing before the seed heads mature. This is doubtless the cheapest and most effective method if done in time, but persistence is essential. Various species of plantain may also gain too much headway. Sheep will keep most of these in check, but they are not relished by cattle.

Recent research by the College of Agriculture has shown that it may ultimately be possible to use certain chemicals in controlling some of the weedy species, such as dock, plantain, and yellow star thistle. In preliminary tests, 2,4-D, at the rate of about ¾ pound of acid equivalent per acre, has controlled these weeds in Ladino clover-grass pastures without any apparent permanent damage either to the clover or grasses. In some of the trials, the clover was temporarily set back, but recovered in two to three weeks. Alfalfa was seriously damaged. Until more is learned about the long-time effect of 2,4-D upon pasture plants, this chemical should be used only on a field-trial basis, and for spot treatment of very weedy areas. The judicious use of a mower before the weeds get too large and go to seed is still the safest recommendation.

Pasture crop rotation. Pastures should be regarded as a crop, and land devoted to pasture should be included in a well-balanced farm program of crop rotation. It should not remain in pasture indefinitely. Weeds can be more effectively controlled by growing a cultivated annual crop on pasture land for a year or two, once every five to seven years. Crop rotation also results in better than normal

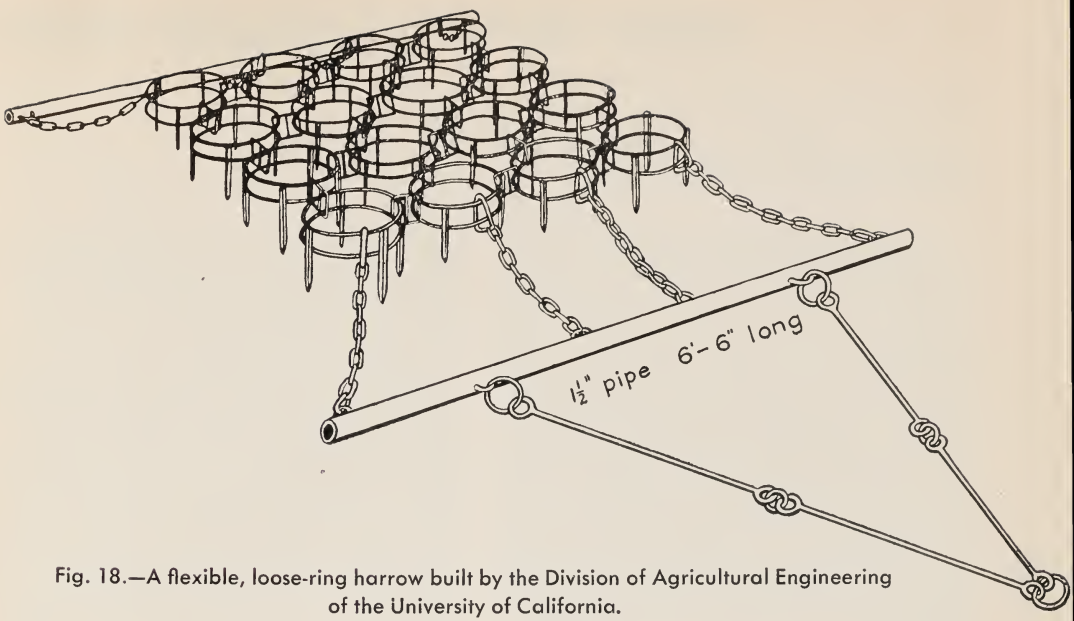

Fig. 18.—A flexible, loose-ring harrow built by the Division of Agricultural Engineering of the University of California.

yields of the annual type feed crops, such as Sudangrass (page 29). Usually a grazier will want to grow feed type crops during this rotation period, to meet his requirements for supplementary feeds.

Irrigated pastures in orchards not advisable. In a few areas, notably Lake, Placer, and El Dorado counties, irrigated pastures have been established in orchards. However, if the pasture is properly irrigated, the trees are usually damaged from overirrigation. Moreover, if arsenical dusts are used for pest control in the orchards, a toxic residue harmful to stock may accumulate on the forage beneath the trees. In addition to grazing on the pasture, the stock also browse on the trees, frequently causing serious damage. Because of these disadvantages, it is probably inadvisable to grow irrigated pastures in orchards.

Ergot poisoning of stock. This poisoning is fairly rare in California, but when it does occur, it results in rather severe damage to stock. A rotational grazing and pasture clipping program which prevents grasses from seeding in late spring and early fall will practically eliminate the condition.

Ergot is a fungus disease which attacks the grasses—principally perennial ryegrass and occasionally Dallisgrass—when they are flowering and making seed. The initial plant symptoms appear at flowering time when a sticky exudate called honeydew covers the seed heads. The exudate attracts flies and insects which spread the disease in the grass plants of the field. As the disease progresses, black, horny bodies called sclerotia develop inside the seeds and destroy them. When these sclerotia are mature, they may either fall to the ground or stay in the seed. In either case, they carry the fungus over winter to reinfect succeeding grass crops. Stock pasturing ergotized fields are usually covered about their heads and bodies with the sticky, black exudate. In heavily ergotized fields, stock may develop varying degrees of nervousness to the point of spasms. In case nervous symptoms develop in grazing stock, they should be moved immediately to other types of pasturage, such as range or stubble, if possible. No clear-cut evidence has yet been obtained to show that, under California conditions, ergotized grass has caused abortion in livestock.

Adding Species to Established Stands

Both Ladino clover and narrowleaf trefoil may be added to established pastures or to stands of Bermuda- or Johnsongrass

Adding legumes to Bermuda- or Johnsongrass stands. Many producers who have dense resident stands of Bermudagrass have been interested in some legume as an associate with it to enrich the feed and increase the carrying capacity. In a number of counties, methods of accomplishing this with Ladino clover have been worked out very satisfactorily. In most cases, the stand of Bermuda has been reduced to a satisfactory ratio, and in a few instances it has been practically eliminated, but this is not a general occurrence.

In seeding Ladino clover in Bermudagrass, it should be remembered that this grass is a summer grower and dormant in late fall and winter. One method is to disk Bermuda thoroughly in the fall and reduce it to as good a seedbed as possible before sowing the clover. Probably the best way to reduce Bermudagrass is to turn it over with a moldboard plow in August, with the soil as dry as possible. Most of the roots are in the top 6 to 8 inches of the soil, and this will expose them to the killing effect of the sun. After 30 to 40 days, the soil is again plowed to expose the other side of the sod to sunlight. Such treatment will kill a high percentage of the plants and their roots. The Ladino will start in the fall and will usually be ready to compete with the Bermuda by the time the latter becomes active in the spring. Bermudagrass will endure more drought than Ladino clover. It is essential to irrigate frequently, especially on the light soils where Bermuda is most likely to thrive, if a satisfactory association is to be achieved. Success is also more likely to follow where the irrigation slope is nearly flat than where there is a considerable grade. It has frequently been shown that 150 to 200 pounds of superphosphate per acre, applied annually, will stimulate the clover and aid in crowding out the grass.

Bermuda frequently thrives in land that is too alkaline for the best growth of Ladino. In such areas, narrowleaf trefoil has been found to be a good legume. This is especially true in seepage areas next to canals or ditches where the trefoil can secure underground moisture. The methods of seeding and management are similar to those given above for Ladino clover and grass mixtures.

Numerous tests in many parts of the state have shown that Ladino clover will also associate with Johnsongrass. Since the growing season of Johnsongrass is similar to that of Bermuda, the seeding practice should be similar. After that, irrigation and management become the deciding factors.

Livestock will consume liberal amounts of Johnsongrass in combination with clover as a natural method of balancing their own ration. But since Johnson is a tall-growing grass, it may soon become too tall and coarse to be relished and will then begin to shade and crowd out the clover. The pasture should then be mowed to reduce the grass competition and promote new and more palatable growth. Johnsongrass will be greatly weakened and may eventually be eliminated if the top growth is kept down, since this gradually saps the plant vitality.

Adding grasses to pure legume pastures. Perennial grasses, such as tall fescue or orchardgrass, cannot be successfully introduced into established stands of pure perennial legumes, such as Ladino clover, by simply broadcasting them into the pasture. The legume stand should be

heavily reduced in the autumn, by disking or harrowing, and ringrolling before the grass seed is sown. If this is carefully done, enough legumes will be left to make reseeding of them unnecessary. The grass should then be seeded and the pasture again ringrolled. Unless some seedbed work is done, the perennial grasses will not be able to compete with the heavy established stand of legumes. Thirty pounds per acre of nitrogen (as commercial fertilizer), applied a few weeks after seeding, has helped stimulate grasses.

A farmer interested in an irrigated pasture primarily from a grazing standpoint should probably make an initial planting of a grass and legume mixture (except for swine alone). If he decides to grow Ladino for seed, he may do so. Seedsmen can separate most types of grass seed from Ladino clover seed with modern seed cleaning equipment. Seed yields per acre may be somewhat lower under this system, but economic livestock gains and minimum bloat trouble are usually the primary interest of the grazier, not seed production.

Adding legumes to "grassy" pastures. Both Ladino clover and birdsfoot trefoil have been successfully reintroduced into pastures which have become predominantly grass. Seed of either or both legumes at the rate of 1 to 2 lbs. per acre of each, is simply broadcast into the pasture in the fall. Some farmers prefer to harrow it in. Subsequent management is important if the endeavor is to succeed. Irrigations should be timed to favor the legumes. A fertilizer (generally phosphorus) which will stimulate only the legumes may also be used. Alfalfa can rarely be introduced in this manner, since it requires a well disked and harrowed seedbed.

Legume and Grass Species Used in Irrigated Pastures

Several species of legumes and grasses are suitable for irrigated pastures. All have their own growth habits, special uses, and limitations

The species recommended for general- and special-purpose mixtures in the various counties are shown in the section on mixtures (pages 50–57). It may be useful, however, to discuss their growth habits, special uses, and limitations.

It has been said that most bunch grasses are too coarse and tufty to make an ideal mixture with Ladino clover. A sod-forming or colony grass, with rootstocks, such as Kentucky bluegrass, would seem better suited to an ideal association with most legumes. No such grasses are now available that are generally adapted to California conditions. At present, it is well to remember that where irrigation water must be applied at frequent intervals, and where other operating and overhead costs are high—as in this state—high production in terms of grazing capacity is a vital consideration. In meeting this requirement, the bunch grasses have no equal among those that are now available. Pasture operators should therefore select those of good feed value that will yield the most pasturage and then adjust management to make the best possible use of them.

Alkali tolerance of species. Irrigated pastures are being used profitably in the San Joaquin Valley and elsewhere in the state to reclaim soils too saline to grow other crops. Through selection of an appropriate combination of saline-

tolerant forage species for the seed mixture, satisfactory production is being achieved on some very difficult sites. The growing grasses and legumes help to speed the reclamation and improvement of the soil. The frequent irrigations required greatly aid in leaching the salts down through the soils. In Monterey County, some very satisfactory pasturage has been developed by using narrowleaf trefoil and grasses to reclaim saline coastal tidelands.

Recently, the U. S. Regional Salinity Laboratory at Riverside, California, published the following list[3] which shows the comparative salinity tolerance of forage species. The list is divided into three groups. **The plants in each group are listed in the order of their saline tolerance—those at the top are most tolerant; those at the bottom, least tolerant.** Although some of the species are not used in irrigated pastures, all have been included, to show their relative rating.

I. GOOD SALT TOLERANCE

Alkali sacaton
Saltgrass
Nuttall alkaligrass
Bermudagrass
Rhodesgrass
Rescuegrass
Canada wild rye
Beardless wild rye
Western wheatgrass

II. MODERATE SALT TOLERANCE

White sweet clover
Yellow sweet clover
Perennial ryegrass
Mountain bromegrass
Barley (cereal)
Birdsfoot trefoil (narrowleaf)
Strawberry clover
Dallisgrass
Sudangrass
Hubam clover
Alfalfa (Calif. Common)
Tall fescue
Rye (cereal)
Wheat (cereal)
Oats (cereal)
Orchardgrass
Blue grama
Meadow fescue
Reed canarygrass
Big trefoil
Smooth bromegrass
Tall meadow oatgrass
Cicer milk vetch
Sour clover
Sickle milk vetch

III. POOR SALT TOLERANCE

White Dutch clover
Meadow foxtail
Alsike clover
Red clover
Ladino clover
Burnet

In addition to differences in salt tolerance among plant species, there are significant differences in strains and varieties. Investigation on this point is continuing.

Ladino clover: A perennial, presumed to be a large form of white Dutch clover. Top and root length varies from 6 inches to over 2 feet, depending on depth, porosity, and fertility of soil. Main stems creep close to the ground, and are rather coarse, with short joints. With favorable moisture, stems lengthen and take root at the joints, so that even a sparse stand soon thickens and becomes dense. (Unlike Dutch clover, Ladino seldom forms new independent plants by this method.) It recovers rapidly after grazing or mowing (often in 2 weeks), and is mostly leafy, not stemmy. It has a growing season as long as that of other available legumes; is winter-dormant in most parts of the state; and undergoes a slight sag during midsummer in warmer parts of the main valleys. The dormant period depends upon severity of the winter. Very sandy soils do not favor Ladino, for moisture in the top foot may be depleted too rapidly to allow economic pasture production. Ladino does not thrive in the high summer temperatures of the Imperial and Palo Verde valleys. Elsewhere in the state,

[3] Mimeograph. Diagnosis and Improvement of Saline and Alkali Soils. L. A. Richards, editor. July, 1947.

it appears to be well adapted when used on appropriate sites.

Alfalfa: California Common, or Chilean alfalfa is generally used. Baltic, Grimm, or Ladak are sometimes seeded where winters are severe. Africa is now being used to some extent in southern California where it makes moderate growth during winter months when most other varieties are dormant. It is not so long-lived as California Common, and will freeze out at colder, higher elevations. Alfalfa is chiefly used on soils too porous for Ladino, but is sometimes used with Ladino to maintain a pasture's legume content during the hottest months. Alfalfa is also used instead of Ladino to seed borders or strips when they have to be made so high that there is not enough moisture for Ladino.

Alsike clover: A perennial chiefly used in the northern counties (Lassen, Modoc, Siskiyou, and eastern Shasta). Farther south (notably the northern Sacramento Valley), it is used in the mixture for heavy soils and for sites where seepage or irrigation water collect in too great amounts for Ladino. It is able to withstand wet, cold, heavy soils better than many other legumes.

Bur clover: A winter annual, in common use in all but the colder sections of California, it is entirely dependent upon seed for reproduction. It does not require seeding, however, except where natural stands have been eliminated or reduced by close pasturing or other farm practices. It is not popular for irrigated pastures north of San Francisco because it is semidormant in winter and does not start much earlier in spring than Ladino. Bur clover grows well in winter in the southern part of the state, and fills the need for a legume to extend the pasture season. A close relative, black medic (*Medicago lupulina*), is used occasionally in southern California for this purpose.

Subterranean clover: An annual with climatic preferences and growth season similar to bur clover. The plant is creeping, soft, and woolly, all parts being covered by fairly long, soft hair. Each leaf is formed of three heart-shaped, faintly toothed leaflets, and is carried on a long stalk. After seeds form, the stems bend down and grow until the seed head is pushed into the soil. This habit of burying its own seed makes the plant equivalent to a perennial. It does well in really acid soils if enough phosphorus is available. General use of this clover is not now recommended although it has proved adaptable in a considerable part of the state. It might well be tested both where bur clover is recommended, and in acid or granitic soils where bur clover does not thrive. The Mt. Barker strain (midseason) is generally used although Late Tallarook (late season) is also doing well on the north coast.

Strawberry clover: A perennial, low-growing plant that spreads by creeping stems that root at the joints. Flower heads are round, pinkish to white in color, and resemble an immature strawberry. It is used in some northern areas of the state, particularly the Tule Lake basin and the coastal plains of Humboldt County. Elsewhere it is chiefly used on soils that are too salty or swampy for Ladino. With ample irrigation, it has survived in the Sacramento and San Joaquin valleys, but is not yet widely used in any of the warmer sections. In those parts, it is at best a low undercover plant that produces some feed and probably contributes some nitrogen to improve soil conditions. Further experience is necessary before its range and usefulness in irrigated pastures in this state can be determined.

Seed of the Palestine strain of strawberry clover is now available on the market. This is a taller form which seems to have more of a winter-growing habit than the common strain. Limited experience indicates that it may become a useful legume in irrigated pastures under conditions to which strawberry clover is adapted.

Narrowleaf or prostrate birdsfoot trefoil: A perennial legume which, in some respects, resembles a fine-stemmed, fine-leaved alfalfa. Stems vary in habit of growth but usually are creeping or spreading, seldom erect. New shoots develop from a crown similar to alfalfa but they are much more branching. Leaves are arranged in groups of five leaflets, three at the end of a short branch, or petiole, and two on opposite sides at the base of the petiole or at the point of attachment with the main branch or stem. Flowers are arranged in rather showy clusters of four to six. They range in color from deep orange to a pale lemon-yellow. Seed pods are straight, cylindrical, usually about 1 inch long and one-eighth inch in diameter. Pods vary in color from green to brown (when ripe). These snap open when ripe and scatter the seed. The two halves of the pod twist into spirals. The clusters of ripened seed pods resemble a bird's foot, hence the common name, birdsfoot trefoil.

This species is very tolerant of alkali conditions and makes a very satisfactory growth where Ladino clover will fail. It is being used with excellent results in the reclamation of alkali soils in the San Joaquin Valley and along coastal tidelands. This species may also find greater use in areas where irrigation water cannot be applied often enough for Ladino clover. Trefoil grows more slowly than Ladino clover, where the latter is adapted, and probably will not replace Ladino for general use.

Some authorities consider the narrowleaf type as a variety of the erect, or broadleaf, type, and have so designated it as var. *tenuifolius*. Research work of recent date shows that narrowleaf trefoil is probably sufficiently distinct to be designated a separate species. It is now being designated by some researchers as *Lotus tenuis*.

Broadleaf or erect birdsfoot trefoil: The species is extremely variable but, in general, shows a more erect type of growth than the narrowleaf type. Authorities designate it as *Lotus corniculatus*. As indicated by the common name, broadleaf trefoil has wider leaflets which may also be shorter than those of narrowleaf trefoil. Flowers of the broadleaf type may also be somewhat larger. In regions of cold winters, broadleaf trefoil may survive where the narrowleaf type is severely damaged or entirely killed.

Until more is known regarding the comparative adaptation of these species, only general recommendations can be made. It appears that the narrowleaf type should be used under very alkaline conditions; the adaptation of broadleaf trefoil to alkali is unknown. At higher elevations, in the absence of alkali, the broadleaf type may be used. Under all other situations requiring trefoil, a mixture of the two types may be advisable.

Annual ryegrass: So much breeding and selection work has been done on the ryegrasses and so many local and trade names have been attached to them that a word of general explanation is needed. Practically all the cultivated ryegrasses originate in two species: *Lolium multiflorum*, most commonly called "Italian ryegrass" or "annual ryegrass," and *L. perenne*, generally called "perennial ryegrass," or "English ryegrass." Some call them both short-lived grass, usually perennial. Various selections of Italian ryegrass are known as "Western-grown," "Oregon-grown," "Domestic," "Wimmera," and "Westerwold." Commercial seed now marketed here is most commonly known as either Western-grown or Domestic ryegrass, and it seems fairly certain that this contains a considerable percentage of hybrids with perennial ryegrass. In any event, parent plants have been known to survive in California for three or four years. Paceys ryegrass, Clunes ryegrass, and many other selections of perennial ryegrass have no outstanding merit above that of the parent. All strains of annual ryegrass can be dis-

tinguished from perennial ryegrass by their emerging leaves, which are rolled, while in the perennial they are folded. Generally there are short bristles on Italian ryegrass seeds and not on perennial, but this characteristic varies widely.

Annual ryegrass is more stemmy and less leafy than perennial. It is popular as an irrigated pasture plant in California because it is very palatable, makes excellent growth, has high production, and early-spring growing habits. The latter quality makes it valuable as early feed and as a moderately good competitor with the flush spring growth of Ladino—hence a valuable bloat preventive. No other grass we now have can compete with it in these respects. It does tend to become dormant in late summer and should be mixed with other grasses to take its place at that season.

Perennial ryegrass: Perennial, or English ryegrass is fully as palatable as Domestic, bears more basal leafage, but does not produce so high a yield. Desirable because it grows later in the summer. In pastures to be used largely for sheep, it is probably better than Domestic. Perennial ryegrass is no longer used in some areas (notably the central coast) because of rust injury, but it is hoped that a rust-resistant strain may eventually become available.

Ryegrass 12: This ryegrass is just coming on the market. It is made up of strains selected by the California College of Agriculture from foundation seed stocks obtained from New Zealand. It is presumably a sister strain of short rotation ryegrass. The original seed, received at Davis, represented selections from an artificial hybrid between annual and perennial ryegrass made by the New Zealand Plant Research Bureau. Ryegrass 12 is morphologically about intermediate between the parents. It produces early fall growth, recovers more rapidly after pasturing or clipping than does either annual or perennial ryegrass, and remains green and grows much longer than annual ryegrass. More uniform, longer-lived strains are being developed. Present strains should be used with the full knowledge that they are variable and may be short-lived. Since it is impossible to distinguish Ryegrass 12 seed from the other types of ryegrass, growers should use only certified seed to be assured of getting the variety ordered.

Orchardgrass: A perennial, readily distinguished by its large, circular bunches, folded leaf blades, and flattened sheaths (especially at the base of the stems). The shape of the flower head has suggested the English name of "cocksfoot." It is coarse and tufty, but has remained popular in pasture mixtures here because it is hardy, persistent, aggressive, and, in the earlier stages, is relished by all classes of livestock including sheep. The latter tend to avoid the main stems and heads, often allowing the plant to become too mature and woody. The coarse, tussocky bunches which result have led to some complaint about this valuable grass. Careful management is essential. Grass should be mowed whenever necessary to keep it from getting beyond the stage of greatest usefulness.

Meadow foxtail: A long-lived, perennial grass. The underground branches are short, so that the grass is in loose tufts. The flowering stems are erect and usually about 3 feet high, and the head is much like that of timothy. It starts growth early in the season, being very tolerant of cold. It is a lover of wet land, but does not thrive in stagnant, saline sites. It is being used to some extent on wetter sites in northern counties and occasionally elsewhere in the state.

Tall fescue: A perennial selection of meadow fescue, but more drought-tolerant. It is thriftier in growth than the parent, with more basal leaves. This selection of meadow fescue has now practically replaced the parent in use for irrigated pastures in California from Imperial to Siskiyou counties. Its long season of growth, high production of forage,

and high degree of palatability for all livestock have resulted in its extensive use and wide popularity. It is now included in pasture mixtures in all counties where it has been given a representative test.

Hardinggrass: A perennial which grows in large, dense, leafy tufts. Once established, it is very persistent. High seed prices and low germination have hindered fullest use of this plant. It is one of the few perennials to make good growth in winter when most other plants are dormant, but will not survive the cold winters of northeastern California. It prefers heavy, black soils and deep volcanic loams, but will produce well on lighter soils underlaid by heavier strata. Though tall and rather coarse, its abundant leaves are relished by all classes of livestock. Only a light seeding (2 to 3 pounds per acre) is recommended to prolong the pasture season in the more temperate parts of the state.

Dallisgrass: A perennial which normally has a deep, strong root system and grows in clumps which tend to die out in the center and enlarge around the edge as the plant ages. Ladino clover plants in association with it are often found occupying the centers of these old clumps. After nearly twenty years of experience, this combination is classed as ideal by graziers who like Dallisgrass. Leaves are numerous near the ground but few on the stems, which are usually drooping or angled. In most of the state (except the colder portions where it will not survive the winters), it starts rather late in the spring and becomes dormant in the fall. But during the summer it recovers more rapidly after grazing than any other grass we have. This factor is disliked by some operators because, like other grasses, it is not so palatable as it gets older. Some irrigation districts oppose the use of this grass because its light, oily seeds float on the water and the plants become established along the ditch banks.

Smooth brome: A perennial, tall-growing, leafy grass that spreads by underground creeping rootstocks which tend to become sod-bound in a few years so that renovation is necessary for best results. Although popular as a hay and pasture plant in northeastern California, it has never found a place in any part of the state where winters are mild and summer temperatures high. General use, therefore, is not recommended.

Kentucky bluegrass: A perennial, true creeping, or colony, grass. While mainly adapted to colder parts of the state, it is not generally recommended there for pasture mixtures. Objections are that it produces too dense a sod and that growth is not luxuriant enough to provide adequate livestock-carrying capacity. In recent years it has been used in parts of the San Joaquin and Sacramento valleys. Some producers believe it has a place there in association with Ladino, especially for sheep. Observations in several counties show that it is crowding out the clover and that it does not yield so much forage as the stronger-growing plants available. This may be partly due to lack of adaptation in those areas. Prospective planters should make observations on local experience, when possible, before planting bluegrass in irrigated pastures.

Rhodesgrass: A perennial, fine-stemmed, leafy grass growing to an average height of nearly 3 feet under favorable conditions. It spreads by running branches which root and produce a tuft at every joint. It will not withstand winter temperatures below 18° F. It is popular in pasture mixtures in the Palo Verde and Imperial valleys, where it is quite at home. Farther north, within its climatic limitations, it is not generally used except in areas that are too alkaline for most other species. It probably has a real place on such sites. Through its ability to absorb alkali salts, however, it may become so saline as to have a scouring effect on livestock. When this is true, the stock should be rotated to less purgative feeds.

Bermudagrass: A perennial which spreads by both surface runners and

underground stems. It is usually considered a pest in California, and the most common demand is for a mixture that will live with Bermuda rather than for seed of this grass for its own value (see page 34). In some interior valleys of San Bernardino County and the Palo Verde and Imperial valleys, it is far more luxuriant than farther north, and has a longer growing season. For this reason, and because it has high feed values, graziers in those areas are not generally opposed to it.

Redtopgrass: A native perennial with a creeping habit of growth which makes a coarse, loose tuft. It is a wet-land type of grass, but will withstand considable drought. Although primarily adapted to mountain meadows and pastures, it may have a place as a sod-former in seepage areas where it will furnish late feed. Its normal maturity dates are similar to those of timothy.

Timothy: A perennial, and, like redtopgrass, a northern species. It is frequently used as a hay and pasture plant in areas of cold winter and moderate summer temperatures, but has never been durable when used in a mixed pasture in the lower elevations of the state.

Burnet: This herb of the rose family has been widely overadvertised as a forage plant in recent years. It is of excellent forage value, but it is a low yielder. It recovers very slowly after mowing or grazing. A tap-rooted perennial, it tends to rosette near the ground. This crowding habit affords it protection against overgrazing and competition of other plants. It is not recommended for irrigated pasture use.

Cost Studies on Irrigated Pastures[4]

Costs of establishing irrigated pastures depend on land preparation required, seed mixture, seed prices, and wage rates. Irrigation is the main annual cost item—400–500 pounds of lamb or beef per acre

Irrigated pasture costs are shown by records obtained by the Agricultural Extension Service in conducting pasture-management studies. Such studies have been carried on at different times in various counties throughout the state since 1936. Recent ones were conducted in Butte, Colusa, Sacramento, San Joaquin, and Yolo counties. Combined averages of all records in these studies are shown in table 3. Since the main purpose of the studies was to develop local information on good management practices as related to production costs, the figures in the tables are not intended to be representative of averages of all pastures in the counties concerned. Wide variations in costs and the amounts of pasturage obtained per acre were found to exist among individual records because of differences in management practices, soil types, kinds of plants in stands, and source of water.

Pasturage in the studies was measured in terms of animal-unit months. An animal-unit month was considered to be equivalent to the average amount of total feed which would be consumed per month by a mature beef animal or a dairy cow producing 200 pounds of milk fat per year. This unit was also considered to be equal to approximately 400 pounds of total digestible nutrients or the equivalent of 0.4 ton of hay. All livestock using

[4] This section was contributed by B. B. Burlingame, Extension Specialist in Farm Management, Berkeley.

pastures were converted to this basis, depending upon their probable total feed consumption. For example, dairy cows giving 400 pounds of milk fat per year were rated at 1.33 animal units, yearling dairy heifers at 0.66 animal unit, lambs (70 to 90 pounds) at 0.15 animal unit, and mature sheep at 0.20 animal unit. Other feed given to animals while they were on pasture was deducted from total feed requirements in calculating the net animal-unit months from pasturage. Any hay harvested was converted to animal-unit months and added to pasturage, but the costs, aside from mowing, were not included.

Pastures in the study ranged in age from 1 to 15 years. The cost of establishing these stands depended largely upon the amount of land preparation required, the seed mixture used, wage rates, and seed prices at time of planting. Original costs varied from a few dollars, where seed was sown in old alfalfa stands, to $30 an acre. Depreciation on most stands was calculated at 10 per cent. Interest on investment charges was computed at 5 per cent of average value of stands, fences, irrigation, and other facilities. Average values for the life of these items were figured at one-half the original cost. Land values used in computing interest costs were based upon normal agricultural values which were somewhat lower than market values during the four years indicated.

Total annual costs on individual pastures in the studies ranged from about $16 to over $50 per year. Pasturage obtained was from 5 to over 20 animal-unit months per acre per year. These wide variations in costs and use resulted in some pastures having a cost per animal-unit month as low as $1 while others ran as high as $7 or more. All records in the four years of the studies averaged $3.14 per animal-unit month. The average cost per 100 pounds of total digestible nutrients supplied by the pastures was one-fourth of this figure, or 79 cents. Hay averaging 50 per cent total digestible nutrients could cost only $7.90 per ton to be equally cheap.

Irrigation was the most important annual cost item in the studies. On the average, a little over 60 per cent of the total cash and labor cost was for water and irrigation labor. Water costs ranged from approximately $2 per acre on land in certain irrigation districts to over $20 where pumping was done from considerable depth. The labor cost of irrigating varied from less than $3 per acre to more than $17 per acre, due to differences in the method of irrigation, size of head, and efficiency of the irrigation system.

Over 90 per cent of the pasturage in the studies was obtained by coöperators during the eight months, March through October, as shown in table 3. Total animal-unit months of pasturage for the four years of the studies averaged 10. Under favorable conditions, well-managed irrigated pastures in the Central Valley of California should produce at least 12 animal-unit months of feed at a total cost not over $30 per acre (as of 1948), which would result in a cost per animal-unit month of $2.50 or less.

Although most pastures in the studies were used by dairy cattle, a few records were obtained on gains in weights of lambs and steers. These indicated that a gross gain, excluding mortality, of between 400 and 500 pounds of lamb or beef is commonly produced from an acre of irrigated pasture after allowances for any supplemental feeds.

Several coöperators in the Colusa County study harvested Ladino clover seed from a portion of their acreage. This is a relatively new practice which paid quite well for some growers during wartime high seed prices. However, it appears that seed production will become a specialized business in itself, not combined with a balanced livestock program, since seed production results in about 2½ to 3 months loss of feed during the middle of the pasture season.

Table 3

SUMMARY OF IRRIGATED PASTURE MANAGEMENT STUDY RECORDS IN NORTHERN CALIFORNIA COUNTIES*

1944, 1945, 1946, and 1947: MATURE STANDS

	1944	1945	1946	1947
Total number of records in studies	26	22	25	24
Total acres covered by records	1,472	919	1,068	1,188
Animal-unit months of pasturage per acre				
January	0.1	0.2	0.1	0.1
February	0.2	0.2	0.2	0.1
March	0.5	0.5	0.5	0.6
April	0.8	0.8	1.0	1.0
May	1.4	1.4	1.5	1.3
June	1.5	1.5	1.5	1.3
July	1.4	1.5	1.2	1.2
August	1.3	1.5	1.1	1.2
September	1.3	1.4	1.1	1.1
October	1.0	1.2	1.0	0.9
November	0.3	0.6	0.4	0.4
December	0.2	0.1	0.2	0.2
Total for year	10.0	10.9	9.8	9.4
COSTS				
Cost per acre:				
Irrigation labor	$ 6.16	$ 7.88	$ 8.69	$ 7.04
Other labor (fence work, fertilizing, clipping, etc.)	1.88	2.69	2.65	1.63
Water cost or power for pumping	5.03	5.07	3.68	5.34
Other materials (seed, fertilizer, etc.)	2.07	4.80	2.14	1.56
County taxes	1.30	1.24	1.44	2.62
General expense and other cash costs	0.99	1.13	1.03	0.80
Depreciation on stand	1.74	1.57	1.79	2.32
Depreciation, irrigation system, fences, etc.	2.25	1.92	2.01	2.56
Total cash and depreciation costs	$21.42	$26.30	$23.43	$23.87
Interest on average value of stands, 5 per cent	$ 0.43	$ 0.42	$ 0.41	$ 0.50
Interest on average value of facilities	0.98	0.91	0.92	1.72
Interest on normal land values	6.28	5.89	5.48	7.03
Total cost of production	$29.11	$33.52	$30.24	$32.62
Total cost per animal-unit month	$ 2.92	$ 3.09	$ 3.09	$ 3.48
Cost per 100 pounds total digestible nutrients†	$ 0.73	$ 0.77	$ 0.77	$ 0.87
Equivalent value of alfalfa hay per ton at above cost of total digestible nutrients	$ 7.30	$ 7.70	$ 7.70	$ 8.70

* Includes records from studies conducted by Agricultural Extension Service in Butte, Colusa, Sacramento, San Joaquin, and Yolo counties.

† Based on one animal unit = 400 pounds total digestible nutrients.

Control of Livestock Parasites on Irrigated Pastures[5]

Irrigated pastures favor development of certain livestock parasites, but this disadvantage may be overcome by routine preventive measures

There are certain internal parasites which infect sheep and cattle. In their mature stages, they inhabit the animal body, where they reproduce. The young, undeveloped parasites are then excreted by the animal, and find conditions in irrigated pastures well suited to their development.

Irrigated pastures are especially good breeding grounds for parasites because: (1) they provide moist conditions and even temperatures at the base of plants (conditions under which parasites thrive); (2) they protect the immature parasites from the drying effects of direct sunlight; (3) they carry more animals per acre than do nonirrigated lands, so that parasite population is higher; (4) they are commonly used for young animals, which are more susceptible to parasites than older ones, and consequently are greater carriers.

In spite of these dangers, irrigated pastures can be used to advantage if the operator will take certain routine measures to suppress parasites and prevent infection.

Coccidiosis. This disease is produced in sheep and cattle when the wall of the intestine is invaded by small, one-celled parasites belonging to the genus *Eimeria*. The infective stages are found in soil and vegetation as a result of being excreted by an infected animal. At this immature stage, considerable moisture is required for rapid growth and development. Because irrigated pastures provide this moisture requirement, coccidiosis of sheep and, particularly, cattle appears to be increasing in California, especially in sections where irrigated pastures are common, and there is an increased concentration of stock.

The most constant symptom of coccidiosis is "bloody scours." Although certain other conditions may produce similar symptoms, whenever such scours occur, coccidiosis should be suspected and a definite diagnosis should be made by a competent person.

Treatment. Experience has shown that placing infected animals on dry feed, particularly nonleguminous hay, usually stops the scouring fairly readily. This treatment may, however, merely relieve the symptoms without necessarily curing the infection. There is no chemical definitely known to be satisfactory in the treatment of coccidiosis in stock. Limited studies on treatment of calves with sulfaguanidine in daily doses of about 5 grams per calf, at the first appearance of symptoms, indicate that this chemical may cure the disease. Comparable results have not been obtained in the treatment of coccidiosis in lambs.

Preventive measures. Coccidiosis may best be prevented by determining, as far as possible, that animals purchased come from "clean" ranches, and when this is not possible, by quarantining new animals, especially young ones, for approximately 2 weeks before they are placed on pastures with other stock. It has been found that, under feed-yard conditions, infections in lambs may be effectively prevented by mixing ground crude sulfur (approximately 150 mesh) with the feed in such quantities that the

[5] This section was contributed by M. A. Stewart, Professor of Parasitology, and Entomologist in the Experiment Station, Berkeley.

final mixture contains from 0.5 to 1.5 per cent sulfur. Concentrations of sulfur in excess of 1.5 per cent produce objectionable laxative effects. The sulfur-feed mixture has been fed for as long as 72 days without ill effects. If the infection has already broken out in the flock, lambs given daily doses of 1 to 3 grams of sulfaguanidine can be protected. Two-tenths per cent by weight of sulfaguanidine in the feed will result in a daily intake in lambs of approximately 3 grams of the drug. Its high cost usually prohibits its use as a preventive measure.

Stomach worms. There are three main types of stomach worm: the large (*Ostertagia*), the small, or microscopic (*Trichostrongylus*), and the twisted wireworm, or eastern stomach worm (*Haemonchus contortus*). The latter is ordinarily of little importance in California.

These worms invade the fourth stomach and small intestine of the animal. The eggs are excreted by the infected animal, hatch, pass through a free-living state (outside the animal), then become infective and crawl up on plants, where they are eaten by the animal. In their free-living stage, the worms require moisture and protection from direct sunlight and drying.

Animals infected with stomach worms, in acute cases, scour, lose weight, and become weak and anemic. The diarrheic feces are typically blackish and of particularly foul odor.

Infections with these parasites are especially common and severe in the fall, winter, and spring months. Infections decrease during the summer, as shown by Furman,[6] because of higher temperatures, and because the immature parasites dry up on the plants. Furman has also shown that in summer more infective worms are found on the upper leaves of Ladino clover than on alfalfa, and more on alfalfa than on Domestic ryegrass. This is probably because the dense shade provided by Ladino gives more protection against drying and high temperatures than do alfalfa and ryegrass. Furthermore, the angles formed by the leaves and stem of Ladino do not keep the immature worms from crawling directly to the higher leaves which are easily reached by the grazing animals. The leaf angles in alfalfa, however, act as a partial block, and those of ryegrasses form an even more effective barrier. The moisture on the surface of the various plants is sufficient during the other months of the year, however, so that there is not much difference in the number of worms in the higher leaves on the three types of plants. The conclusion is that Ladino clover is a more favorable breeding ground for stomach-worm infection during summer months than is alfalfa or western ryegrass. Moisture and temperature conditions, however, are such that even on Ladino, serious infections may be expected only during fall, winter, and spring months, and at that time there is enough moisture on all pasture plants so that there is little difference between numbers of parasites on Ladino and on alfalfa or ryegrass.

Treatment. Stomach-worm infections in sheep and cattle may be successfully treated with cunic mixture, which is made up in the following way:

1. Make a stock solution of 2 pounds of copper sulfate in 1 gallon of water in a wooden or earthenware container.

2. To 1 pint of the above solution, add 11½ quarts of water to make 3 gallons.

3. To this 3 gallons of copper sulfate solution add 4 fluid ounces of 40 per cent nicotine sulfate (Black Leaf 40).

4. Steps 2 and 3 may be repeated as needed. This is better than mixing all the amount at once as the completed mixture deteriorates on standing.

The dosage for a full-grown ewe is 4 fluid ounces, graduated to 2 ounces for lambs 3 months old. Since cattle have a

[6] Furman, Deane P. Effects of environment upon the free-living stages of *Ostertagia circumcincta* (Stadelmann) *Trichostrongylidae:* I. Laboratory experiments. Amer. Jour. Vet. Res. 5:79–86. 1944. II. Field experiments. Amer. Jour. Vet. Res. 5:147–53. 1944.

lower tolerance for nicotine, the dosage is 3½ ounces for animals weighing more than 150 pounds. The drug is administered with a drenching syringe. It is recommended that the animals be kept off food and water for 12 hours before treatment and be starved for another 2 hours after treatment. It is usually most practical to drench in the morning. If cunic mixture is given in too large doses, fatal poisoning may result. Animals which have been shipped some distance and starved en route should be fed the night before treatment to prevent their absorbing too much of the drug. Care must be taken during drenching to make sure that none of the solution gets into the lungs.

Phenothiazine is practically 100 per cent effective in the treatment of twisted wire-worm infections. It is less efficient, but still good, against *Trichostrongylus axei, Ostertagia circumcincta,* and *O. trifurcata.* All these nematodes occur in the fourth stomach. This drug is not satisfactory in the elimination of the so-called "stomach worms" that localize in the small intestine. Phenothiazine may be given as a bolus, in gelatin capsules, or as a drench. It is given at a dosage rate of 25 grams for sheep and 15 grams for lambs weighing up to 60 pounds. Cattle are given from 50 to 80 grams and calves from 24 to 40 grams. This drug should not be given to animals that are markedly anemic, weakened, and emaciated, nor to constipated animals, since such animals cannot tolerate it and consequently may be severely poisoned.

Most animals will accept phenothiazine in the feed, but group feeding of the drug may be dangerous since some animals, particularly those in a thriving condition, may eat considerably more than their share of the material. Group feeding is unreliable so far as dosage rate is concerned. However, the administration of phenothiazine mixed in feed may be considered suitable for animals fed individually or where the drug is given for preventive rather than curative purposes.

Preventive measures. Stomach-worm infections on irrigated pastures can be prevented to a large extent by treating all new animals with cunic mixture before they are placed on the pasture and, in heavily infected areas, by treating the animals every 3 weeks from the time they are 3 weeks old.

Phenothiazine-salt mixtures in concentrations of not more than 1 part phenothiazine to 9 parts salt or less than 1 part phenothiazine to 14 parts salt are of some value, at least, as a means of preventing clinical infections with the nematodes against which the drug is effective. Also, it is claimed that under such circumstances, sufficient phenothiazine is eliminated by the animal to prevent the development of infective larvae in the feces and thus heavy "seeding" of pastures with infective larvae is avoided. This method of prevention of clinical infection is effective only at those seasons of the year (late fall, winter, and early spring, in California) when heavy infections are acquired. These mixtures are not of curative value after infections producing acute symptoms have been acquired.

Furman (see footnote 6, p. 45) has shown that stomach-worm larvae will remain alive on irrigated pastures sown to Ladino clover or alfalfa for at least 200 days, including the summer months, and also that the larvae will migrate upward through 12 inches of plowed soil. Plowing followed by rotation might be of some value in controlling pasture infestations.

Nodular worms. Another group of parasites known as "nodular worms" (*Oesophagostomum*) cause a disease which produces symptoms similar to those caused by stomach worms, but in acute cases they may be more serious than the latter. Generally these worms become a serious problem only in those regions where summer rains occur, but it is possible that moisture conditions in irrigated pastures may increase the problem in California.

Treatment. Phenothiazine is the only drug known to be effective in the treatment of nodular-worm infections. The dosage rates are the same as those recommended for the treatment of stomach-worm infections. The same preventive measures also apply.

Liver flukes. The liver fluke (*Fasciola hepatica*) is a small, brownish-gray, somewhat leaf-shaped organism about 1 inch long. The severity of the disease caused by the fluke itself is determined by the general condition of the infected animal and by the number of flukes it is harboring. In sheep, animals that are only moderately infected fail to gain weight properly, are poor mothers, and are easy prey to such diseases as pneumonia, hemorrhagic septicemia, and lungworm infections; heavier infections may result (in addition to extensive liver damage) in rupture of the liver capsule and hemorrhage into the abdominal cavity. In very acute infections in sheep, which are rare, the animal dies suddenly with bleeding from the nostrils and anus, suggesting anthrax. In more typical cases, the sheep shows an elevated temperature and is off color. This is followed by an anemia with "bottle-jaw" and marked muscular weakness. The skin becomes dry and the wool is dry and brittle. There may occasionally be diarrhea or constipation. Such animals may either die or recover.

Liver flukes in sheep are involved in the occurrence of the serious bacterial infection, black disease. The flukes carry the black disease bacteria on their bodies, from the intestine to the liver. The young flukes destroy the liver tissue, thus aiding the bacterial growth.

The clinical picture of liver-fluke infection in cattle is somewhat different from that in sheep. Constipation is marked and the feces are hard and brittle. Diarrhea occurs only in the extreme stages. Emaciation occurs rapidly and the animals, especially calves, are soon prostrated. Heavier infections are necessary to produce clinical symptoms in cattle than in sheep. Many times cattle are infected heavily enough for their livers to be condemned in the slaughterhouse but not sufficiently to produce obvious symptoms.

The life history of the liver fluke is more complicated than that of the other parasites discussed. Adult flukes which are located in the bile ducts of the liver deposit tremendous numbers of eggs which are carried into the small intestine with the bile, and voided with the feces of the infected animals. The eggs hatch in the presence of water. The eggs do not develop at temperatures below 50° F, but will remain alive for several months. The young fluke (*miracidium*), when hatched from the egg, swims about in search of an appropriate species of water snail, which will act as an intermediate host. Only certain species of snails are suitable for this purpose. After the miracidium invades the snail host, it develops and multiplies until it reaches the *cercaria* stage. Each miracidium which enters the snail produces about 300 cercariae. These escape from the body of the snail, swim about in the water, and eventually work their way up on various meadow and swamp grasses and water plants. Here they glue themselves to the plants in the form of small white cysts, just below the water level. When these infested plants are eaten by the animal, the young flukes escape from the cysts into the small intestine and burrow through the intestinal wall. After this, they wander about in the body cavity for a time—sometimes occurring in tremendous numbers—and finally reach the liver. There they penetrate the capsule and burrow through the liver tissue for a month or more, finally reaching the minute bile tubes down which they pass to the bile ducts, where they reach maturity.

The cysts may remain alive on vegetation for a considerable time, even over winter. They can successfully resist mild drying and low temperatures, but high temperatures are rapidly fatal. They are able to exist on dry hay for a few weeks,

and if it is not properly dried, the cysts may remain infective on it for a year or more.

Treatment. Liver-fluke infections in sheep may be treated successfully by the administration of carbon tetrachloride or tetrachloroethylene in 1-cc. doses. If the sheep have not had access to pasturage or feed containing legumes, or other sources of calcium, they either should be placed on such a feed for a few weeks before treatment with either of these drugs, or a few animals should be given a preliminary treatment under the observation of a veterinarian, to determine the effect of the drug. Treatment should not be given soon after a change of feed. Carbon tetrachloride or tetrachloroethylene should not, in general, be given if the animal is unusually fat, if it is on a high protein and fat diet, or during lactation.

Cattle have a low tolerance for both carbon tetrachloride and tetrachloroethylene. Therefore, these drugs should not be used for the treatment of bovine infections with liver flukes. Hexachloroethane is the most satisfactory drug known for the treatment of liver-fluke infections in cattle. It is given in capsules at a dosage rate of 3 ounces for adult animals. Younger animals are given proportionately smaller doses.

Preventive measures. Several surveys have been made by the author to determine whether or not liver-fluke infections were being acquired on irrigated pastures in California, and in no instance has such been found to be true. These investigations have shown so far that when cases of fluke infections were present in animals on irrigated pastures they were actually acquired elsewhere. It has been stated, however, that liver-fluke infections have been acquired on irrigated pastures in Mendocino County. It is true that appropriate intermediate snail hosts may occur on such pastures and it is possible that liver-fluke infections may result. The chief danger lies in the possibility that a snail-host population may build up in the irrigation ditches and that the immature flukes, escaping from the snails, may be transported to the plants during irrigation.

Effective snail control is the only practical means of controlling liver-fluke infections in irrigated pastures. Copper sulfate (bluestone) is the most efficient chemical known for this purpose, but care must be taken not to apply it to streams or other bodies of water in which there are fish because it is more toxic to them than to snails. It should not be applied to irrigated pastures in large quantities over long periods of time since it is possible that the copper content of the soil may be built up to such an extent as to slow down, or possibly prevent the growth of forage plants.

The strength of the copper sulfate solution used depends upon the amount of decomposing organic matter in the water. In California, it is usually used in standing water at the rate of 1 part copper sulfate to 1,000,000 parts water (1 ounce to 7,800 gallons), and is repeated at the end of a month to kill those snails that were in the egg stage at the time of the first treatment.

In the treatment of flowing streams, select a uniform section of stream. Measure the average width and depth. Find the speed at which the water travels (feet per second) by finding how many seconds it takes a small piece of wood to float a measured distance. Next, multiply the width times depth times speed times 6. This will give the amount of copper sulfate, at a dilution of 1 part per 1,000,000 parts of water, needed to treat each mile of stream. If there is a considerable amount of decomposing vegetation in the water, the amount of chemical used should be correspondingly increased. Remember, these concentrations of copper sulfate will kill fish. Place the necessary amount of copper sulfate crystals in a burlap sack and suspend a sack in the stream at intervals of 1 mile.

Snails in or on the mud of the banks of the stream, above the water level, will not be killed. These banks, therefore, should be treated in the same way as swamps and marshes. Marshes and similar moist places may be treated by mixing thoroughly 1 part granulated copper sulfate with from 4 to 8 parts sand or road dust and broadcasting or dusting the mixture at the rate of from 10 to 30 pounds per acre. The amount of copper sulfate in the mixture and the rate at which the mixture is applied are determined by the amount of surface water present. Greater areas of surface water require stronger mixtures and larger quantities of the mixture. Attention is again drawn to the possible danger of ruining the soil by applying too much copper sulfate over too long a period of time.

It is necessary to make a second application one month after the first, in all of the methods described above. Three or four days after the first treatment, the area should be searched for live snails, to determine the effectiveness of the treatment; if it has been ineffective, probably too weak a concentration of copper sulfate was used. This treament is not effective in controlling snails in cold weather since they burrow into the mud during winter.

After the second application, inspections should be made approximately every 3 months during the spring, summer, and fall, to determine whether or not reinfestations are occurring.

On the following pages, you will find both general- and special-purpose mixtures recommended for each county in California, and for special soil conditions within those counties.

The space provided below is for your convenience in keeping a record of the mixture particularly suited to your own irrigated pasture. It is suggested that you fill out this blank and keep it on hand for reference.

MY PASTURE MIX **SEEDING DATE**.....

LEGUMES	Lbs./Acre	Total lbs. required	GRASSES	Lbs./Acre	Total lbs. required

MIXTURES RECOMMENDED BY COUNTY FARM ADVISORS

COUNTY	GENERAL-PURPOSE MIXTURE (species and lbs. per acre)	SPECIAL-PURPOSE MIXTURE (species and lbs. per acre)
ALAMEDA	Ladino clover, 3; annual ryegrass, 1; perennial ryegrass, 2; orchardgrass, 3; tall fescue grass, 4; *total, 13;* occasionally added or substituted: alfalfa, 2; narrowleaf trefoil, 1.	On marshy or slightly alkali land: Ladino clover, 1; narrowleaf trefoil, 2; yellow sweet clover, 2; annual ryegrass, 2; perennial ryegrass, 2; tall fescue grass, 4; *total, 13;* occasionally added or substituted: alfalfa, 2.
BUTTE	Ladino clover, 3; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 3; tall fescue grass, 4; *total, 14;* occasionally added or substituted: alfalfa, 2; narrowleaf trefoil, 2; Dallisgrass, 3.	
COLUSA	Ladino clover, 4; Ryegrass 12, 4; tall fescue grass, 3; *total, 11;* occasionally added or substituted: narrowleaf trefoil, 2; orchardgrass, 3; Dallisgrass, 3.	On alkali land: Ladino clover, 3; narrowleaf trefoil, 3; Dallisgrass, 4; tall fescue grass, 3; *total, 13.* On riverbottom land: Alfalfa, 3; Ryegrass 12, 3; tall fescue grass, 4; *total, 10.*
CONTRA COSTA	Ladino clover, 3; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 3; tall fescue grass, 4; *total, 14.*	On moderately alkali land: Ladino clover, 1; narrowleaf trefoil, 2; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 1; Dallisgrass, 2; tall fescue grass, 4; *total, 14.* On very alkali land: Narrowleaf trefoil, 2; yellow sweet clover, 2; annual ryegrass, 2; perennial ryegrass, 1; Dallisgrass, 2; tall fescue grass, 2; Rhodesgrass, 3; *total, 14.*
EL DORADO	Ladino clover, 3; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 3; tall fescue grass, 4; *total, 14.*	
FRESNO	Ladino clover, 2; alfalfa, 2; bur clover, 2; perennial ryegrass, 2; orchardgrass, 2; Dallisgrass, 2; tall fescue grass, 2; *total, 14.*	On light, sandy land: Alfalfa, 4; bur clover, 2; perennial ryegrass, 2; orchardgrass, 2; Dallisgrass, 2; tall fescue grass, 2; *total, 14.* On molybdenum problem land: Alfalfa, 6; perennial ryegrass, 2; orchardgrass, 2; Dallisgrass, 2; tall fescue grass, 2; *total 14.* (In severe molybdenum districts omit all legumes from mixture.)

COUNTY	GENERAL-PURPOSE MIXTURE (species and lbs. per acre)	SPECIAL-PURPOSE MIXTURE (species and lbs. per acre)
HUMBOLDT	Ladino clover, 5; annual ryegrass, 7½; perennial ryegrass, 7½; *total, 20;* occasionally added or substituted: alfalfa, 20; alsike clover, 10.	
IMPERIAL	Alfalfa, 8; bur clover, 1½; Dallisgrass, 8; tall fescue grass, 8; *total, 25½.*	
KERN	Ladino clover, 2; alfalfa, 1; annual ryegrass, 2; perennial ryegrass, 4; orchardgrass, 2; Dallisgrass, 2; tall fescue grass, 7; *total, 20.*	On valley sandy land: Alfalfa, 2; yellow sweet clover, 1; annual ryegrass, 3; perennial ryegrass, 3; orchardgrass, 2; tall fescue grass, 7; Rhodesgrass, 2; *total, 20.* On mountain valley land: Ladino clover, 1; alfalfa, 1; broadleaf trefoil, 1; strawberry clover, 1; annual ryegrass, 2; perennial ryegrass, 3; orchardgrass, 2; tall fescue grass, 6; tall oatgrass, 3; *total, 20.* On molybdenum problem land: Annual ryegrass, 2; perennial ryegrass, 3; Dallisgrass, 3; tall fescue grass, 8; Rhodesgrass, 2; *total, 18;* occasionally added or substituted: alfalfa, 2.
KINGS	Ladino clover, 2; alfalfa, 2; bur clover, 2; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 3; tall fescue grass, 3; *total, 16.*	
LAKE	Ladino clover, 3; annual ryegrass, 2; perennial ryegrass, 2; Dallisgrass, 3; tall fescue grass, 4; *total, 14;* occasionally added or substituted: alfalfa, 1.	On marshy or subirrigated land: Narrowleaf trefoil, 1; alsike clover, 3; annual ryegrass, 5; orchardgrass, 2; Hardinggrass, 1; *total, 12.*
LASSEN	Alfalfa, 2; perennial ryegrass, 2; orchardgrass, 3; smooth bromegrass, 3; tall oatgrass, 3; crested wheatgrass, 2; *total, 15;* occasionally added or substituted: alsike clover, 1; yellow sweet clover, 2.	
LOS ANGELES (except Antelope Valley)	Ladino clover, 3; bur clover, 2; annual ryegrass, 3; perennial ryegrass, 3; orchardgrass, 3; Dallisgrass, 3; tall fescue grass, 3; *total, 20;* occasionally added or substituted: alfalfa, 3; barley, 10.	

COUNTY	GENERAL-PURPOSE MIXTURE (species and lbs. per acre)	SPECIAL-PURPOSE MIXTURE (species and lbs. per acre)
MADERA	Ladino clover, 2; alfalfa, 2; narrowleaf trefoil, 1; bur clover, 2; annual ryegrass, 2; orchardgrass, 2; Dallisgrass, 2; tall fescue grass, 2; *total, 15.*	On moderately alkali land: Alfalfa, 2; narrowleaf trefoil, 1; strawberry clover, 1; alsike clover, 2; yellow sweet clover, 2; annual ryegrass, 2; orchardgrass, 2; Dallisgrass, 2; tall fescue grass, 2; Rhodesgrass, 1; *total, 17.* On strongly alkali land: Narrowleaf trefoil, 2; strawberry clover, 2; alsike clover, 2; yellow sweet clover, 2; white sweet clover, 2; tall fescue grass, 3; Rhodesgrass, 2; *total, 15.* On very sandy land: Alfalfa, 3; bur clover, 2; yellow sweet clover, 2; orchardgrass, 3; Dallisgrass, 2; tall fescue grass, 3; *total, 15.*
MARIN	Ladino clover, 3; narrowleaf trefoil, 1; perennial ryegrass, 3; orchardgrass, 3; tall fescue grass, 3; Hardinggrass, 1; *total, 14.*	
MENDOCINO	Ladino clover, 4; perennial ryegrass, 6; orchardgrass, 6; *total, 16.*	On coastal and semicoastal land: Subterranean clover, 4; perennial ryegrass, 5; orchardgrass, 5; Hardinggrass, 2; *total, 16.* On inland meadow land: Bur clover, 4; perennial ryegrass, 8; Hardinggrass, 2; *total, 14.*
MERCED	Ladino clover, 2; alfalfa, 2; narrowleaf trefoil, 1; annual ryegrass, 3; perennial ryegrass, 3; tall fescue grass, 3; *total, 14;* occasionally added or substituted: bur clover, 2; orchardgrass, 2; Dallisgrass, 3.	On alkali land: Ladino clover, 2; narrowleaf trefoil, 1; yellow sweet clover, 2; annual ryegrass, 3; perennial ryegrass, 3; Dallisgrass, 3; tall fescue grass, 2; Rhodesgrass, 2; *total, 18;* occasionally added or substituted: orchardgrass, 2. On sandy land: Ladino clover, 2; alfalfa, 2; yellow sweet clover, 2; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 2; Dallisgrass, 2; tall fescue grass, 2; *total, 16.*
MODOC	Alfalfa, 2; alsike clover, 2; red clover, 2; perennial ryegrass, 5; orchardgrass, 4; tall fescue grass, 5; *total, 20.*	On shallow land, frequently irrigated: White Dutch clover, 4; strawberry clover, 1; smooth bromegrass, 6; Kentucky bluegrass, 4; *total, 15.*

MIXTURES RECOMMENDED BY COUNTY FARM ADVISORS—*Continued*

COUNTY	GENERAL-PURPOSE MIXTURE (species and lbs. per acre)	SPECIAL-PURPOSE MIXTURE (species and lbs. per acre)
MODOC (continued)		On alkali land: Alfalfa, 1; strawberry clover, 2; white sweet clover, 2; perennial ryegrass, 3; tall fescue grass, 4; smooth bromegrass, 4; Kentucky bluegrass, 1; *total, 17.*
MONTEREY	Ladino clover, 3; alfalfa, 1; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 3; tall fescue grass, 4; *total, 15.*	
NAPA	Ladino clover, 4; annual ryegrass, 3; perennial ryegrass, 3; tall fescue grass, 5; *total, 15.*	On marshy or alkali land: Narrowleaf trefoil, 3; annual ryegrass, 3; perennial ryegrass, 3; tall fescue grass, 5; *total, 14.* On deep, open land: Alfalfa, 8; annual ryegrass, 3; perennial ryegrass, 3; tall fescue grass, 5; *total, 19.*
NEVADA	Ladino clover, 3; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 2; tall fescue grass, 3; *total, 12.*	
ORANGE	Ladino clover, 3; bur clover, 3; annual ryegrass, 3; perennial ryegrass, 3; orchardgrass, 4; tall fescue grass, 4; *total, 20.*	On alkali land: Bur clover, 2; strawberry clover, 2; yellow sweet clover, 3; annual ryegrass, 3; tall fescue grass, 4; Rhodesgrass, 4; *total, 18.* On land under limited irrigation: Alfalfa, 2; narrowleaf trefoil, 2; bur clover, 2; yellow sweet clover, 2; annual ryegrass, 2; tall fescue grass, 3; Rhodesgrass, 3; Hardinggrass, 2; burnet, 2; *total, 20.*
PLACER	Ladino clover, 3; alfalfa, 2; annual ryegrass, 2; perennial ryegrass, 1; tall fescue grass, 3; *total, 11.*	
PLUMAS	Alsike clover, 4; tall fescue grass, 4; smooth bromegrass, 8; *total, 16;* occasionally added or substituted: alfalfa, 4; orchardgrass, 4.	
RIVERSIDE	Ladino clover, 2; bur clover, 3; annual ryegrass, 1; perennial ryegrass, 4; orchardgrass, 2; tall fescue grass, 5; *total, 17.*	On land under limited irrigation: Narrowleaf trefoil, 2; bur clover, 3; annual ryegrass, 2; orchardgrass, 2; Dallisgrass, 2; tall fescue grass, 4; burnet, 2; *total, 17.* For the Coachella and Palo Verde valleys: Alfalfa, 4; annual ryegrass, 2; Dallisgrass, 6; tall fescue grass, 6; Bermudagrass, 4; *total, 22.*

MIXTURES RECOMMENDED BY COUNTY FARM ADVISORS—*Continued*

COUNTY	GENERAL-PURPOSE MIXTURE (species and lbs. per acre)	SPECIAL-PURPOSE MIXTURE (species and lbs. per acre)
SACRAMENTO	Ladino clover, 4; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 4; tall fescue grass, 4; *total, 16;* occasionally added or substituted: alfalfa, 2.	On riverbottom, deep land: Ladino clover, 2; narrowleaf trefoil, 2; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 4; tall fescue grass, 4; *total, 16;* occasionally added or substituted: alfalfa, 2.
SAN BENITO	Ladino clover, 3; alfalfa, 3; perennial ryegrass, 3; orchardgrass, 3; tall fescue grass, 3; Hardinggrass, 3; *total, 18.*	On alkali land: Narrowleaf trefoil, 3; yellow sweet clover, 2; perennial ryegrass, 3; orchardgrass, 3; tall fescue grass, 3; Hardinggrass, 3; *total, 17.*
SAN BERNARDINO	Ladino clover, 3; bur clover, 3; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 3; Dallisgrass, 2; tall fescue grass, 4; barley or oats (nurse crop), 15; *total, 34;* occasionally added or substituted: alfalfa, 5.	For the Mojave River Valley: Ladino clover, 1; alfalfa, 4; black medic, 1; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 3; Dallisgrass, 2; tall fescue grass, 4; barley (nurse crop), 15; *total, 34;* occasionally added or substituted: yellow sweet clover, 2. On wet or mountain meadows: Ladino clover, 2; alsike clover, 3; annual ryegrass, 3; smooth bromegrass, 3; timothy, 3; Kentucky bluegrass, 3; redtopgrass, 3; *total, 20.*
SAN DIEGO	Ladino clover, 3; alfalfa, 2; annual ryegrass, 1; perennial ryegrass, 2; orchardgrass, 3; tall fescue grass, 2; Hardinggrass, 1; *total, 14.*	On alkali land: Narrowleaf trefoil, 2; strawberry clover, 3; orchardgrass, 3; tall fescue grass, 3; Rhodesgrass, 3; *total, 14.* On light, sandy land: Alfalfa, 4; annual ryegrass, 2; orchardgrass, 3; tall fescue grass, 3; Rhodesgrass, 3; *total, 15.*
SAN JOAQUIN	Ladino clover, 3; annual ryegrass, 3; perennial ryegrass, 2; orchardgrass, 3; tall fescue grass, 4; *total, 15.*	
SAN LUIS OBISPO	Ladino clover, 3; alfalfa, 3; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 2; tall fescue grass, 2; *total, 14.*	On land under limited irrigation: Alfalfa, 4; yellow sweet clover, 3; orchardgrass, 2; Dallisgrass, 3; tall fescue grass, 2; Hardinggrass, 2; *total, 16.*
SAN MATEO	Ladino clover, 3; alfalfa, 1; narrowleaf trefoil, 1; subterranean clover, 2; perennial ryegrass, 1; orchardgrass, 1½; tall fescue grass, 2; Hardinggrass, ½; *total, 12.*	

MIXTURES RECOMMENDED BY COUNTY FARM ADVISORS—*Continued*

COUNTY	GENERAL-PURPOSE MIXTURE (species and lbs. per acre)	SPECIAL-PURPOSE MIXTURE (species and lbs. per acre)
SANTA BARBARA	Ladino clover, 2; alfalfa, 3; narrowleaf trefoil, 2; annual ryegrass, 4; orchardgrass, 1; Dallisgrass, 1; tall fescue grass, 3; Rhodesgrass, 1; Hardinggrass, 2; *total, 19.*	
SANTA CLARA	Ladino clover, 3; narrowleaf trefoil, 1; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 2; tall fescue grass, 4; *total, 14;* occasionally added or substituted: Dallisgrass, 1.	On land under limited irrigation: Alfalfa, 1; narrowleaf trefoil, 2; perennial ryegrass, 2; orchardgrass, 2; tall fescue grass, 3; Hardinggrass, 2; burnet, 1; *total 13;* occasionally added or substituted: Dallisgrass, 1.
SANTA CRUZ	Ladino clover, 3; alfalfa, 2; annual ryegrass, 2; orchardgrass, 3; tall fescue grass, 4; *total, 14.*	
SHASTA	Ladino clover, 3; narrowleaf trefoil, 2; annual ryegrass, 4; orchardgrass, 3; tall fescue grass, 4; *total, 16;* occasionally added or substituted: alfalfa, 2; Dallisgrass, 4.	On marshy or subirrigated land: Broadleaf trefoil, 2; alsike clover, 4; annual ryegrass, 3; perennial ryegrass, 3; Dallisgrass, 5; *total, 17.* On wet or mountain meadows: Broadleaf trefoil, 2; strawberry clover, 3; Reed canarygrass, 5; *total, 10.*
SISKIYOU	Ladino clover, 4; perennial ryegrass, 4; orchardgrass, 4; tall fescue grass, 4; smooth bromegrass, 4; *total, 20.*	On poorly drained land: Alsike clover, 4; meadow foxtail grass, 4; Reed canarygrass, 8; *total, 16.*
SOLANO	*For cattle:* Ladino clover, 1½; alfalfa, 2; narrowleaf trefoil, 1½; perennial ryegrass, 2; orchardgrass, 2; tall fescue grass, 3; *total, 12;* occasionally added or substituted: Dallisgrass, 2. *For sheep:* Alfalfa, 1–2; narrowleaf trefoil, 3–5; perennial ryegrass, 3; *total, 7–10;* occasionally added or substituted: Ladino clover, 3.	On marshy or subirrigated land: Narrowleaf trefoil, 3; tall fescue grass, 3; meadow foxtail grass, 3; *total, 9.*
SONOMA	Ladino clover, 3; Ryegrass 12, 3; tall fescue grass, 5; Hardinggrass, 1; *total, 12;* occasionally added or substituted: alfalfa, 3.	On land under limited irrigation: Ladino clover, 2; narrowleaf trefoil, 2; orchardgrass, 1; tall fescue grass, 3; *total, 8;* occasionally added or substituted: alfalfa, 2.
STANISLAUS	Ladino clover, 4; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 4; tall fescue grass, 2; *total, 14.*	On light, sandy land: Ladino clover, 2; alfalfa, 4; yellow sweet clover, 6; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 4; *total, 20.*

MIXTURES RECOMMENDED BY COUNTY FARM ADVISORS—*Continued*

COUNTY	GENERAL-PURPOSE MIXTURE (species and lbs. per acre)	SPECIAL-PURPOSE MIXTURE (species and lbs. per acre)
SUTTER	Ladino clover, 3; annual ryegrass, 2; perennial ryegrass, 2; tall fescue grass, 4; *total, 11;* occasionally added or substituted: alfalfa, 2; narrowleaf trefoil, 1.	
TEHAMA	Ladino clover, 2; alfalfa, 3; annual ryegrass, 4; orchardgrass, 3; Dallisgrass, 2; tall fescue grass, 2; *total, 16*	On shallow land: Ladino clover, 2; narrowleaf trefoil, 1; annual ryegrass, 4; orchardgrass, 3; Dallisgrass, 2; *total, 12;* occasionally added or substituted: tall fescue grass, 2. On land under limited irrigation: *For shallow land:* narrowleaf trefoil, 2; annual ryegrass, 4; perennial ryegrass, 2; orchardgrass, 3; Dallisgrass, 2; *total, 13.* *For deep land:* Alfalfa, 4; annual ryegrass, 4; perennial ryegrass, 2; orchardgrass, 3; Dallisgrass, 2; *total, 15.* On wet or mountain meadows: Ladino clover, 3; broadleaf trefoil, 2; alsike clover, 5; perennial ryegrass, 2; orchardgrass, 5; tall fescue grass, 3; *total, 20.*
TRINITY	Ladino clover, 2; narrowleaf trefoil, 1; broadleaf trefoil, 1; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 3; tall fescue grass, 4; *total, 15.*	
TULARE	*For cattle and sheep:* Ladino clover, 1–2; alfalfa, 1; bur clover, 2; annual ryegrass, 4; orchardgrass, 3; tall fescue grass, 3–4; *total, 14–16.* *For hogs:* Ladino clover, 4; alfalfa, 4; bur clover, 2; *total, 10.*	On light, sandy land: *For cattle and sheep:* Alfalfa, 1–2; bur clover, 2; yellow sweet clover, 1–2; annual ryegrass, 4; orchardgrass, 3; tall fescue grass, 3–4; *total, 14–17.* *For hogs:* Alfalfa, 6; bur clover, 2; yellow sweet clover, 2; *total, 10.* On alkali land: *For cattle and sheep:* Narrowleaf trefoil, 1–2; bur clover, 2; strawberry clover, 1; yellow sweet clover, 1; annual ryegrass, 3–4; tall fescue grass, 4; Rhodesgrass, 2; *total, 14–16.* *For hogs:* Narrowleaf trefoil, 3; bur clover, 2; strawberry clover, 2; yellow sweet clover, 1; *total, 8.*

MIXTURES RECOMMENDED BY COUNTY FARM ADVISORS—*Concluded*

COUNTY	GENERAL-PURPOSE MIXTURE (species and lbs. per acre)	SPECIAL-PURPOSE MIXTURE (species and lbs. per acre)
TUOLUMNE	Ladino clover, 3; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 3; tall fescue grass, 4; *total, 14.*	
VENTURA	*For cattle and sheep:* Ladino clover, 1; alfalfa, 4; black medic, 1; Ryegrass 12, 2; orchardgrass, 3; Dallisgrass, ½; tall fescue grass, 3; Rhodesgrass, ½; Hardinggrass, 1; *total, 16.* *For horses:* Alfalfa, 3; black medic, 1; Ryegrass 12, 2; orchardgrass, 1; Dallisgrass, 3; tall fescue grass, 4; Rhodesgrass, 1; Hardinggrass, 1; *total, 16.* *For hogs:* Ladino clover, 1; alfalfa, 10; black medic, 1; *total, 12.*	On shallow land: *For cattle and sheep:* Ladino clover, 3; alfalfa, 1; black medic, 1; Ryegrass 12, 3; orchardgrass, 3; Dallisgrass, ½; tall fescue grass, 3; Rhodesgrass, ½; *total, 15.* *For horses:* Ladino clover, 2; black medic, 1; Ryegrass 12, 2; orchardgrass, 1; Dallisgrass, 3; tall fescue grass, 4; Rhodesgrass, 1; *total, 14.* *For hogs:* Ladino clover, 4; alfalfa, 1; black medic, 2; *total, 7.*
YOLO	*For beef cattle and sheep:* Ladino clover, 4; *total, 4;* occasionally added or substituted: narrowleaf trefoil, 4. *For dairy cattle:* Ladino clover, 4; perennial ryegrass, 2; tall fescue grass, 2; *total, 8;* occasionally added or substituted: narrowleaf trefoil, 4.	
YUBA	Ladino clover, 3; annual ryegrass, 2; perennial ryegrass, 2; orchardgrass, 3; tall fescue grass, 4; *total 14.*	

In order that the information in our publications may be more intelligible it is sometimes necessary to use trade names of products or equipment rather than complicated descriptive or chemical identifications. In so doing it is unavoidable in some cases that similar products which are on the market under other trade names may not be cited. No endorsement of named products is intended nor is criticism implied of similar products which are not mentioned.

Coöperative Extension work in Agriculture and Home Economics, College of Agriculture, University of California, and United States Department of Agriculture coöperating.
Distributed in furtherance of the Acts of Congress of May 8, and June 30, 1914.
C. W. Rubel, Acting Director, California Agricultural Extension Service.

Contents

30*m*-6,'49 (B3342)

48 Ways to solve a problem
Farm Advisors . . .

located in 48 California counties and in these towns:

Alturas
Auburn
Bakersfield
Colusa
Cowell
Eureka
El Centro
Fresno
Fairfield
Grass Valley
Hayward
Hanford
Hollister
Half Moon Bay
Kelseyville
Los Angeles
Madera
Merced
Modesto
Marysville
Napa
Oroville
Placerville
Quincy
Riverside
Redding
Red Bluff
Susanville
San Rafael
Salinas
Santa Ana
Sacramento
San Bernardino
San Diego
Stockton
San Luis Obispo
Santa Barbara
San Jose
Santa Cruz
Santa Rosa
Sonora
Ukiah
Visalia
Ventura
Yreka
Yuba City
Weaverville
Woodland

AGRICULTURAL EXTENSION SERVICE
U. S. DEPARTMENT OF AGRICULTURE AND UNIVERSITY OF CALIFORNIA

CALIFORNIA AGRICULTURAL EXTENSION SERVICE
UNIVERSITY OF CALIFORNIA • BERKELEY